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Fungi Causing Decay of Living Oaks in the Eastern United States and Their Cultural Identification [1]

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[2] Salary paid from funds furnished by the Civilian Conservation Corps.

INTRODUCTION

The fungi that decay the heartwood of living oaks have very different damaging abilities. Papers on heart-rotting fungi of oak by von Schrenk and Spaulding (*40*),[3] Hedgcock (*16*), Hedgcock and Long (*17*), and Long (*23*, *25*) were based on either localized studies or scattered observations of fruiting bodies and types of rot found. Fruiting bodies are found relatively infrequently in direct association with the rots. Vanin (*38*), Hepting (*18*), Davidson (*12*), and Boyce (*3*) have recently pointed out that the identification of the causal organism from the type of rot is usually not possible at present. This is clearly shown from the lists of common fungi published by Hepting (*18*) and Roth and Sleeth (*34*), which include numerous species not mentioned in the earlier publications.

In the studies covered by the last two publications an attempt was made to isolate the decay fungus from every infected tree examined and to identify the isolates by their cultural characteristics. This same method was used in additional studies in other areas and in other types of oak stands throughout the Eastern and Central States. The isolation and cultural identification method was thus tested by an extensive study of one host genus. Throughout these studies it was shown that except for one or two pocket rots, or where odor was a distinguishing character, the fungi involved could not be definitely identified until they were obtained in pure culture.

In the following different types of stands an attempt was made to determine the important heartwood-decaying fungi: (1) Unburned sprout stands; (2) seedling or seedling sprout stands that had been damaged by fire; and (3) southern Delta hardwood stands. A key to and descriptions of the decay fungi in culture are given.

FACTORS AFFECTING RELATIVE-PREVALENCE FIGURES FOR DECAY FUNGI

Methods of Sampling

The methods of obtaining samples of heartwood decay are of considerable importance in an attempt to get an accurate picture of the relative prevalence of the fungi in a given stand. As most of the studies were not planned to give data on prevalence alone the various sampling methods will be enumerated. Hepting (*18*) and Roth and Sleeth (*34*) have described their methods so that a discussion of them is unnecessary. Liming [4] used methods similar to those of Roth and Sleeth except that a definite number of each of the principal oak species was cut on each plot chosen. Later, while making a general survey through Ohio, Illinois, Iowa, and Missouri, Liming took miscellaneous samples from decayed stumps and cull logs on logging areas or from individual trees. Lorenz and Christensen [5] also obtained samples of decay from cull logs and stumps in southern Michigan, Ohio, and Missouri. The samples from Michigan and Ohio were obtained from recently logged areas, whereas those from Illinois, Iowa, and Missouri were mostly taken at the time of cutting.

[3] Italic numbers in parentheses refer to Literature Cited, p. 63.

[4] Liming, F. G. Unpublished data.

[5] Lorenz, Roland C., and Christensen, Clyde M. A survey of forest tree diseases and their relation to stand improvement in the Lake and Central States. U. S. Dept. Agr., Bur. Plant Indus. 52 pp., illus. 1937. [Mimeographed.]

Noecker [6] obtained numerous samples from individually selected defective trees at Willow Springs and Ava, Mo., in 1935. Later a study was initiated at Bunker, Mo., under the direction of Roth, as reported by Limstrom and Kuenzel,[7] and the clear-cut method of tree sampling was used. The same method was used at Elizabethtown, Ill.[8] In West Virginia, North Carolina, Kentucky, and Tennessee samples were obtained by Roth and Garren [9] from decay of butts and tops of individually selected fire-wounded white oak.

In part of the sprout oak butt rot study, samples were selected from various heights in the trees. One was usually taken from typical decay, one from incipient decay, one from just above incipient decay, and one or two at 1-foot intervals from the visibly sound heartwood above incipient decay. A sample was also taken from the butt of each apparently sound sprout. In all of the other studies mentioned only one or two samples were obtained from each infected part of a tree and these were taken from either typical or incipient decay. The samples were approximately 2 to 4 inches long, 1½ to 2½ inches wide, and ½ to 1 inch thick. An attempt to isolate the decay organism from the samples was usually made as soon as they arrived at the Washington office, but in some cases they were held for several days at a storage temperature of about 50° F. In making the isolations the block was split open, the freshly exposed surface was quickly flamed, and chips of decay were transferred to two or more test tubes of malt agar with the aid of a flame-sterilized chisel forceps. The test-tube plantings were then incubated at room temperature for from 2 to 3 weeks before they were examined. If no fungus appeared in the test tubes a second attempt was sometimes made, but as a rule such attempts were also unsuccessful.

Throughout this bulletin records on prevalence represent number of infections and not number of isolations.

Identification and Isolation Difficulties

After the fungi had made sufficient growth in test tubes they were examined and identified or notes were taken on type of growth and the cultures were held for later study. During most of the time when field work was in progress so many samples were being handled in the laboratory that very little time could be given to the study of individual isolates. An attempt was made to hold all cultures that were associated with decay, but inadvertently some were lost and the records on type of growth, etc., were not always adequate for later identification. On the other hand, the common well-known species, such as *Polyporus dryophilus*, *P. sulphureus*, *Hydnum erinaceus*, and *Stereum frustulosum*, were usually readily recognized and a definite record was made of the species involved.

The species of heartwood-decaying fungi known to be important in oaks can with a few exceptions now be readily identified in pure culture. *Polyporus obtusus* and *Irpex mollis* are very similar in

[6] Noecker, N. L. Unpublished data.

[7] Limstrom, G. A., and Kuenzel, J. G. Factors affecting the extent of defect in certain upland hardwoods on the Clark purchase unit in Missouri. Unpublished report, Central States Forest Expt. Sta., U. S. Dept. Agr. 1937.

[8] Kuenzel, J. G. Decay in fire-scarred trees in mixed upland hardwood stands on the Shawnee purchase unit in southern Illinois. Unpublished report, Central States Forest Expt. Sta., U. S. Dept. Agr. 1936.

[9] Roth, Elmer, and Garren, K. H. In unpublished paper by G. H. Hepting on decay following fire in Appalachian oaks.

microscopic and macroscopic characteristics, so that a more intensive study will have to be made before they can be separated with certainty. *Polyporus croceus* has a number of closely related poroid forms, which may possibly be confused with it. Some of the species isolated were not regarded as causing decay of heartwood and some may have been merely invading wood that was already decayed.

A rather large proportion of the decay from some of the areas yielded only molds and other non-decay-producing fungi. Possibly some species of decay-producing fungi are less tolerant than others to mold growth and would therefore be obscured in attempts to isolate them on artificial culture media. Throughout this study, however, there were no indications that the oak fungi differed greatly in this respect.

Type of Stand

The type of stand was one of the most influential factors determining the prevalence of the various decay fungi. In sprout stands with many parent stumps *Stereum gausapatum* was usually the most prevalent fungus. In seedling or seedling-sprout stands or sprout stands that had been altered by early fires, other fungi were commonly present. In stands that were badly fire-wounded, butt rot fungi other than *S. gausapatum* were more prevalent. Top or trunk-inhabiting species were more prevalent than butt-rotting species in open stands with large branches. The southern Delta oaks yielded some fungi that were not present in other areas sampled.

The age of a stand or rather the length of time of exposure to infection may have some influence on the species of fungi found to be most prevalent. Unquestionably, heartwood in the butts of sprouts from stumps over 2 inches in diameter and in trees injured by early fires would be exposed to infection at a much earlier time than would the heartwood in the tops. Old-growth stands often have considerable top damage so that top- or trunk-inhabiting fungi are common. Young stands are relatively free of such fungi.

IDENTIFICATION OF FUNGI ISOLATED FROM OAK DECAYS

Pure-culture descriptions of 50 species associated for the most part with decay in living oaks of various ages and from widely separated localities are given in detail. These descriptions are based, wherever possible, on authentic sporophore isolations. The number of sporophore cultures available for each species is listed in a previous paper by the authors (*13*). Several of the fungi, notably *Irpex cinnamomeus*, *Daedalea confragosa*, and *Schizophyllum commune*, rot dead sapwood only but have been included in order to make the list as complete as possible. Several others, including *Polyporus pargamenus*, *P. versicolor*, and *Stereum rameale*, are usually associated with sap rot, but have been isolated a few times from heart rot. *Fomes robustus* has been isolated only from sporophores or from rot with which a sporophore was associated. The same is true of *Irpex mollis*. All the others have been isolated from rot with which no sporophores were associated. As a result of these studies a number of fungi that were not previously known to cause important heart rot in oaks were obtained. Several of these, including *Stereum gausapatum* (*4*, *12*) and *Poria andersonii* (*7*), were important enough to warrant separate

published notes. Other fungi, not previously known to cause heart rot in living oaks, include: *Corticium lividum (4), Merulius tremellosus, Polyporus compactus, Poria cocos, P. inflata, P. nigra, Poria* sp., and an unidentified fungus which in culture resembles *Polyporus zonalis.*

Methods Used To Identify Decay Fungi

GENERAL PROCEDURE

Usually the initial identification of a fungus isolated from decay is made by comparison with isolates previously obtained from sporophores, or from rot back of sporophores. In order to facilitate identification of decay fungi, the Division of Forest Pathology maintains a collection of cultures isolated from identified sporophores of wood-decaying fungi.[10] Because past experiences indicate that much decay is caused by fungi formerly not considered important in this respect, a systematic effort has been made to obtain isolates from any species that might conceivably be associated with decay. Unfortunately, many decay fungi form evanescent or inconspicuous sporophores, often at irregular intervals, so that systematic collecting must be carried on for many years before any collection of wood-decaying fungi can be considered reasonably complete. Occasionally a species was identified from sporophores produced in pure culture, even though such sporophores were often badly distorted in shape. However, such identifications were verified wherever possible by cultures from sporophores of the species produced in nature. Sporophores produced in culture, even if abortive and distorted, are important in suggesting taxonomic relationships and hence give valuable clues as to the type of fungus to search for in the field.

The identification of fungi obtained from rot, whose cultural characteristics are known, can usually be made from test-tube cultures without difficulty. However, certain species may resemble each other so closely in tube cultures as to require special treatment in order to distinguish them. Special treatment is also required in the comparison of unidentified isolates with the sporophore isolates maintained in the culture collection. This treatment consists of cultural methods designed to compare macroscopic, microscopic, and physiological characteristics. Detailed studies of cultural characteristics are used for comparing different isolates and to enable other workers to make like comparisons.

CULTURE MEDIUM

Unless otherwise stated, all Petri-dish and test-tube descriptions given here are for cultures grown on 1.5-percent Difco malt with 2-percent agar autoclaved 20 minutes at 15 pounds' pressure. However, for routine laboratory use, 2.5-percent Fleischmann's diamalt gave results comparable to 1.5-percent Difco malt. No attempt was made to measure the amount of agar in Petri dishes. An average of 30 dishes was obtained from 1 liter of malt agar, making the amount approximately 35 cc. to a dish.

[10] Ralph Nelson started this collection of sporophore cultures in 1928. To these the authors have added many during the past 7 years until the present collection represents approximately 250 species. The authors are greatly indebted to Irene Mounce, L. O. Overholts, Frank Kaufert, Ray Hirt, and Clyde Christensen for additions to this collection. Most of the sporophores from which cultures were obtained were identified by L. O. Overholts. Dow V. Baxter has assisted in the identification of some of the *Poria* species.

OXIDASE TEST

The oxidase test, as described by Bavendamm (*1*), was made by growing the fungi to be tested on malt agar containing 0.5 percent of gallic or tannic acid. Fungi causing brown rot do not form dark discolored areas under the fungus mat, i. e., are negative in reaction, and fungi causing white rot form dark discolored areas and are thus considered positive reactors. A few exceptions have been encountered in diagnosing rot type by the oxidase test but in most cases the above generalization holds true. The information concerning the oxidase reactions for the different species treated in this study have been taken from a previous recording by Davidson, Campbell, and Blaisdell (*13*).

CONSTANT-TEMPERATURE STUDIES

Most wood-destroying fungi possess characteristic optimum and growth-inhibiting temperatures. For this reason average mat diameters for the different fungi were determined at 20°, 25°, 30°, 35°, and 40° C., or as near these temperatures as possible, in incubators with a normal variation range of not more than 0.5°. As the value of such studies depends upon maintaining experimental conditions as constant as possible the following procedure was adopted: Pieces of inoculum 3–4 mm. square were taken from Petri-dish or young test-tube cultures and placed mycelium side down upon the medium in 90-mm. Petri dishes that contained approximately 35 cc. of malt agar. In order to prevent excessive drying of the agar and to keep the fungi in complete darkness, the inoculated dishes were inverted and placed in cans fitted with tight covers. The dishes were inverted in order to prevent condensed moisture from drowning out the mycelium. The cultures were kept 1 day at room temperature before placing them in the incubators. This was done in order to allow the mycelium to become established in the agar before placing at temperatures which, at 35° or 40°, were often adverse for growth. Growth measurements, as mat diameters, were taken at the end of 7 days for slow-growing species whose mats did not exceed 9 cm. in diameter at their optimum temperature in that time. For faster growing species data were taken at corresponding shorter periods. The average mat diameters for the different species reported here are taken, with few exceptions, from the mat diameters of eight separate isolates.

Despite the precautions taken to keep experimental conditions and temperatures as constant as possible, certain species, for example *Corticium lividum* and *Poria cocos*, showed so much variation between isolates and between the same isolate on repeated trials that any average figures would be misleading. However, in such cases, the optimum temperature remained constant, and this optimum alone is reported. Most species gave consistent results on repeated trials with the same or different isolates.

Results are reported as averages and hence variations were present both on the plus and minus side. A comparison of the optimum temperatures reported here with those reported by Humphrey and Siggers (*22*) and Cartwright and Findlay (*9*) shows close agreement with some species and considerable differences with others. Some of the variation may be due to differences in methods and some is no doubt due to variations in strains of the fungi studied.

MACROSCOPIC CHARACTERS USEFUL IN IDENTIFICATION

The colors exhibited by the mycelium of wood-destroying fungi in culture, at 7 and 14 days, fall into several well-defined groups. A fungus may be white or colorless at all ages; it may start as a white mycelium gradually becoming yellow or brown within 7 to 14 days; it may be entirely yellow or brown after 1 or 2 days; it may be some shade of pink or orange; and occasionally it may show color that does not fit well into any general scheme. Because light influences color formation and some fungi are much inhibited by direct sunlight or strong light, it has been found most satisfactory to describe color as it develops in diffused light.

In general appearance mats are either appressed, that is, do not extend much above the agar surface, or are raised, producing a definite mound of mycelium. Intermediate conditions are common. A mat is free if the surface mycelium can be peeled or readily scraped from the underlying agar. The mat is adherent if the surface mycelium and the agar form an inseparable layer. The terms used to describe the texture of the mat are those proposed by Long and Harsch (*26*) and restated by Campbell (*5*). The need for more concise descriptions of mats formed by fungi in culture has necessitated a careful definition of certain terms. These are described in detail in the legend for figure 1.

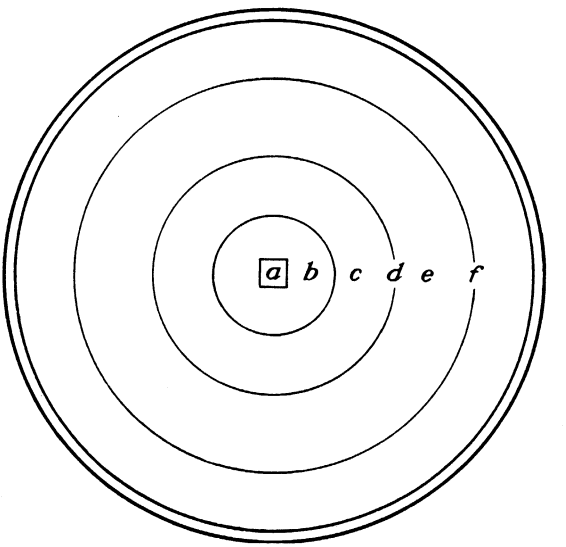

FIGURE 1.—Diagrammatic drawing of a fungus mat as ordinarily formed in Petri-dish cultures. *a*, Inoculum. *b*, The center or area around the inoculum. *c*, Central zone, or that portion of the mat surrounding the center and delimited from the rest of the mat by a difference in color or texture. If the boundary, *d*, of the central zone is sharply defined the term definite is used; if the boundary gradually blends with the rest of the mat the term indefinite is used. If the central zone has a radius of less than half the radius of the mat it is restricted; if more than half, extensive. If no qualifying term is used the central zone should be considered as having a radius approximately equal to half the radius of the mat. *e*, The marginal zone. *f*, Margin proper, or zone of advancing growth.

Growth rate, at a given temperature in a definite medium, is a fairly constant characteristic of a particular species, except as previously noted, and is expressed for Petri-dish cultures as colony diameter in centimeters at 7 or 14 days. For ordinary observations these diameters are taken at room temperature, which in the case of the species reported here averaged 26° C.

MICROSCOPIC CHARACTERS USEFUL IN IDENTIFICATION

In general, microscopic structures were found to be less variable than macroscopic features and hence more useful in identification (*5*, *28*).

Microscopic examinations were made of mycelium mounted in 5-percent potassium hydroxide (KOH) and stained by erythrosin or eosin. Potassium hydroxide solution was preferable to water as certain color reactions, specific for several fungi, were revealed without extra manipulation. However, many crystals are soluble in potassium hydroxide and unless these are noted when the mount is fresh, additional mounts may be needed to show uneroded crystals. Microscopic observations of fast-growing fungi, especially those with a tendency to form tough mats, should be made at 7 days in order to note size and form of actively growing hyphae. Additional observations are necessary at 14 days in order to check changes in size and condition of hyphae, and to note spore formation. The presence or absence of clamp connections is an important character. At times they may be so scattered as to be missing from most mounts. They should be considered lacking if one or more cannot be seen in each field containing a mass of hyphae which stain with erythrosin or eosin. Although differences were found between species as to the form and size of clamps, all attempts to describe adequately such differences proved more confusing than helpful.

Other microscopic structures useful in identification and classification include: Chlamydospores, conidia, oidia, basidia and basidiospores, cuticular cells, staghorn or abnormal hyphal branches, setal hyphae, and setae. In some cases all the mycelium of 14-day-old cultures will stain with erythrosin or eosin (with the exception of collapsed, empty hyphae); in other cases, hyaline nonstaining hyphae will be present. Classification into submerged and superficial hyphae is rather confusing at times, and it has been found more satisfactory to distinguish between "staining" hyphae and "nonstaining" or fibrous hyphae. The latter system was used in this study and the term "staining hyphae" refers to all aerial or submerged hyphae with a content that stains red with erythrosin or eosin, and "nonstaining" to those hyphae with thick or thin hyaline or colored walls, without living content and nonstaining. Usually there will be gradations between the two forms, as most fibrous, nonstaining hyphae start as thin-walled strands that gradually lose their content and form thick walls. A description of staining and nonstaining hyphae is given with the usual size range in microns.

The Effect of Variation on the Identification of Fungi by Pure-Culture Methods

Certain studies, notably those of Mounce (*27*), Verrall (*39*), Herrick (*20*), and Childs (*11*), dealing with a large number of isolates of a single wood-decaying fungus, have shown that considerable variation may exist between such isolates in pure culture. Variations are apparent not only in the color of the mycelium, texture of the mats, and growth rate, but also in essentially physiological activities, such as the ability to decay wood. Cultural studies based on a single isolation may be misleading, because one can never be certain that the isolate at hand represents average behavior or an extreme. The great majority of isolates of a given species will vary within reasonable limits and only a small percentage will show excessive variation. Analysis of the several variation studies and a consideration of the fungi encountered in the oak-decay study indicate this to be true.

Considerable difficulty is often encountered in interpreting widespread variation among isolates from supposedly the same species. Mycologists have often grouped together fungi with similar morphological characters regardless of other considerations. In some cases such species complexes have been composed of fungi associated with both brown and white rots. Cultural studies have been helpful in clearing up certain misconceptions as to species relationships as in the case of the *Poria* on birch (*6*), *Poria andersonii* (*7*), and *Polyporus glomeratus* Pk. (*7*).

The value of cultural identification of wood-destroying fungi is well demonstrated in the present study. Only three fungi for which any great number of isolates were available could not be identified. One was definitely determined as a species of *Poria*, but further classification is not possible until additional work can be done with species of the group or complex to which it belongs.

A miscellaneous collection of unknowns for which only one or two isolations of each were encountered still remains, but these were not considered sufficiently important to spend further time in identifying and describing.

One should not gather from the above that variations are not important, but merely that these variations should not interfere with the identification of the greater portion of the fungi isolated from rot by fungi whose cultural characteristics are well known. Usually identification is made after consideration of several important characteristics, and considerable variation in one or several of these features, does not render the isolation unidentifiable. Single-spore isolations and also mass-spore isolations seem to vary more than tissue or rot isolations and, for general culture work with wood-destroying fungi isolations from the latter sources, are preferable.

Classification and File System

With an increase in the number of identified and unidentified fungi associated with decay, the problem of classification for comparison and reference becomes increasingly important. A card index system has been developed by the Division of Forest Pathology whereby the cultural characteristics of different fungi may be recorded and arranged in a key for ready reference and comparison.

The index cards used to record pertinent data about fungi in culture, as illustrated by figure 2, are printed on lightweight cardboard 8½ by 11 inches. The reverse side gives some directions for use and descriptions of the various terms and also provides space for photographs and additional information. Reference to the sample card, that of *Polyporus hispidus*, shows that macroscopic and microscopic characters, as well as certain physiological reactions, are considered in analyzing the cultural characteristics of a fungus and in arriving at a key pattern which is used for filing purposes. The cultural methods used to obtain these data and the several descriptive terms are the same as those mentioned in detail in a previous section.

The first column is concerned with the more obvious aspects of a fungus in culture, such as color of fungus mat and rate of growth. The oxidase reaction is also included to separate white rot fungi from brown rot fungi. As *Polyporus hispidus* is yellow in culture at both 7 and 14

days, "C" is checked on the card and the color according to Ridgway (*33*) is written on the line following "color." *P. hispidus* is positive by the oxidase test and "P" is checked. In case the test cannot be made, in using the index cards, brown rot fungi should be tentatively considered negative and white rot fungi positive. *P. hispidus* forms a mat 6–7 cm. in diameter in 14 days at room temperature, and, therefore, it belongs in class M, and this letter is checked on the card and the actual growth rate in 7 or 14 days is written in the blanks below.

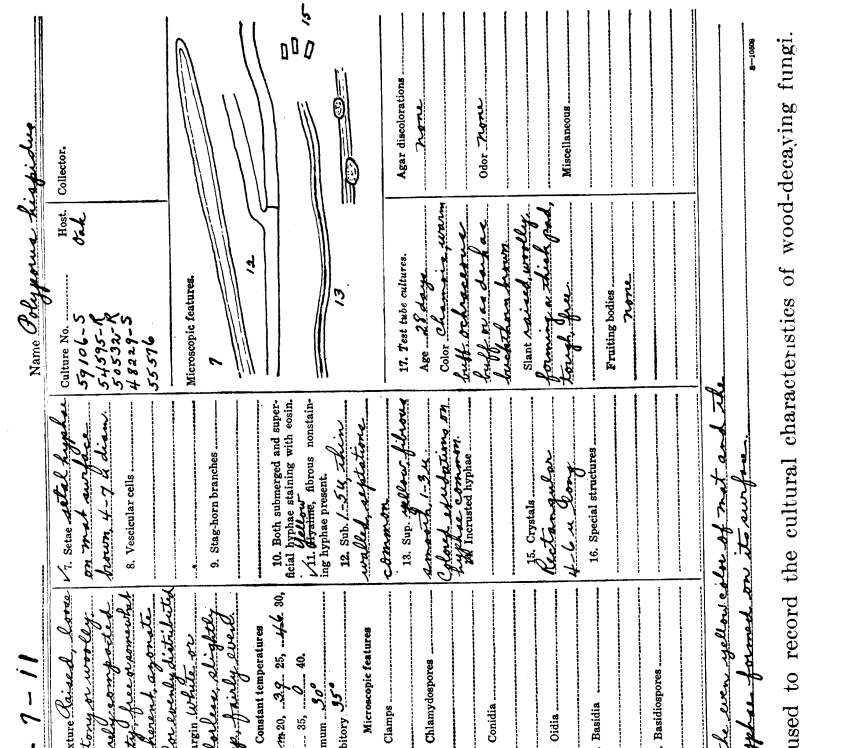

FIGURE 2.—Card used to record the cultural characteristics of wood-decaying fungi.

At the top of the second column, texture of mat and marginal characters are listed. Experience shows that these characters vary considerably with light, moisture, and temperature, and are at times difficult to describe; therefore, they are not used to formulate the key pattern.

In a microscopic study of a fungus, only those structures listed on the card that are actually present in the mycelium of the fungus being studied should be checked. Those not checked are considered absent.

Polyporus hispidus does not have clamps or spores, therefore no record is made; setal hyphae are present; therefore "7" is checked and a description entered in the space provided. As fibrous, nonstaining hyphae are present, "11" is checked. The actual hyphal sizes are listed under "12" and "13."

Data for test-tube cultures are taken preferably at 28 days. These data should include color, texture on slant and agar cylinder, fruiting bodies, agar discolorations, and odor.

A space at the top of the fourth column is provided for information concerning the origin of the culture or cultures. The important microscopic structures are sketched in the open space underneath. At the bottom of the card a line is left for remarks concerning distinguishing characteristics. Because color and the presence of setal hyphae are the most characteristic features of *Polyporus hispidus*, this information is written in. To complete the data on the card, a Petri-dish photograph of the fungus taken at 14 days is pasted to the back.

The file pattern is now ready to be placed at the top of the card. This is obtained from the checked data and will be an expression of the macroscopic and microscopic characters of the fungus. For *Polyporus hispidus* this is C–P–M–7–11. In filing a number of these cards by the file pattern, the order as to color would be A, B, C, etc. The fungi that are negative by the oxidase test are segregated from those that are positive. Fungi having different growth rates are also separated. Sometimes a fungus will fall on the border line in respect to a key character. In such cases, the species must be filed under two heads in respect to the disputed character. The advantage in dealing with a large number of fungi comes from the ability to tell the important cultural features of any fungus at a glance. In this way unnamed fungi may be filed away for ready reference and comparison with new acquisitions or already named fungi. A key to the 50 fungi studied in culture is arranged according to their file patterns.

KEY TO OAK-DECAYING FUNGI WHEN GROWN ON MALT AGAR

The following key is based on the classification system previously described. The first letter refers to mat color in 14 days in diffused light. A, white at all ages; B, white then yellow or brown; C, yellow; D, brown; E, pink or orange; and F, any color not fitting well into the first five divisions.

The second letter refers to the oxidase reaction. O, negative or brown rot fungi; P, positive or white rot fungi.

The third letter refers to growth rate as mat diameter in centimeters at room temperature averaging 26° C.; F, rapid, over 9 cm. in 7 days; I, moderately rapid, over 9 cm. in 14 days but less than 9 cm. in 7 days; M, medium, 5–9 cm. in 14 days; S, slow, 2–5 cm. in 14 days; V, very slow, less than 2 cm. in 14 days.

The numbers refer to microscopic structures: 1, clamps; 2, chlamydospores; 3, conidia; 4, oidia; 5, basidia; 6, basidiospores; 7, setae; 8, vesicular or cuticular cells; 9, staghorn or abnormal branching of the hyphae; 10, all hyphae staining with erythrosin; 11, nonstaining hyphae present; 14, incrusted hyphae; 16, special structures or reactions; 17, some distinctive characteristic in tube cultures.

In the key only those characters that are actually present are listed; characters not listed should be considered absent. In practice such microscopic characters as hyphal sizes and crystals were not sufficiently distinct to use in the key. In separating the fungi with the same key pattern, reference must be made to the cultural descriptions.

Key Pattern of Fungi Isolated from Oaks

Key pattern	*Fungus name*
A–O–I–1–2–11	*Polyporus spraguei.*
A–O–I–1–2–11–16	*Schizophyllum commune.*
A–O–M–1–2–5–6–11	*Daedalea quercina.*
A–O–M–1–2–5–6–11–16	*Poria* sp.
A–O–M–1–2–11	*Polyporus spraguei.*
A–O–M–1–2–11	*Poria nigra.*
A–O–M–1–2–11	*Daedalea quercina.*
A–O–M–1–2–11–16	*Poria* sp.
A–O–M–2–10	*Poria inflata.*
A–O–M–2–3–10	*Poria inflata.*
A–O–M–10–16	Unidentified agaric.
A–P–F–1–2–3–11	*Polyporus fissilis.*
A–P–F–1–11	*Polyporus versicolor.*
A–P–F–5–6–11	*Fomes geotropus.*
A–P–F–11	*Fomes geotropus.*
A–P–I–1–2–5–6–11	*Polyporus compactus.*
A–P–I–1–2–11	*Polyporus lucidus.*
A–P–I–1–2–11	*Polyporus compactus.*
A–P–I–1–2–11	*Polyporus obtusus.*
A–P–I–1–2–11	*Irpex mollis.*
A–P–I–1–2–11–16	*Schizophyllum commune.*
A–P–I–1–2–10–16	*Polyporus frondosus.*
A–P–I–1–11	*Polyporus pargamenus.*
A–P–I–1–11–17	*Pleurotus ostreatus.*
A–P–I–2–4–8–9–11	*Polyporus zonalis.*
A–P–I–10–16	Unidentified fungus.
A–P–M–1–2–10–16	*Hydnum erinaceus.*
A–P–M–1–2–10–16	*Polyporus frondosus.*
A–P–M–1–2–11	*Polyporus obtusus.*
A–P–M–1–2–11	*Irpex mollis.*
A–P–M–1–8–9–11	*Fomes applanatus.*
A–P–M–2–5–6–11	*Polyporus berkeleyi.*
A–P–M–2–10–16	*Hydnum septentrionale.*
A–P–M–10–16	Unidentified agaric.
B–O–M–1–2–11	*Poria nigra.*
B–O–M–11–16	*Stereum frustulosum.*
B–O–S–1–2–11–14	*Fistulina hepatica.*
B–P–F–1–2–11–17	*Lentinus tigrinus.*
B–P–F–1–11–16	*Stereum rameale.*
B–P–I–1–2–5–6–11–16	*Corticium lividum.*
B–P–I–1–2–7–11	*Polyporus graveolens.*
B–P–I–1–2–11	*Polyporus lucidus.*
B–P–I–1–8–9–11	*Fomes lobatus.*
B–P–I–1–11	*Daedalea confragosa.*
B–P–I–1–11–16	*Stereum rameale.*
B–P–I–1–11–16	*Stereum gausapatum.*
B–P–I–11	*Polyporus gilvus.*
B–P–M–1–2–3–10–17	*Pholiota adiposa.*
B–P–M–1–8–9–11	*Fomes lobatus.*
B–P–M–1–11	*Daedalea confragosa.*
B–P–M–11	*Polyporus gilvus.*
B–P–S–2–11–17	*Hymenochaete rubiginosa.*
B–P–S–8–11–16	*Armillaria mellea.*
B–P–S–11	*Polyporus ludovicianus.*
B–P–S–11–17	*Hymenochaete rubiginosa.*
B–P–V–8–11–16	*Armillaria mellea.*

Key pattern	*Fungus name*
B–P–V–11–16	*Polyporus dryadeus.*
C–P–I–11	*Irpex cinnamomeus.*
C–P–M–7–11	*Polyporus hispidus.*
C–P–M–7–11	*Poria andersonii.*
C–P–M–11	*Fomes everhartii.*
C–P–M–11	*Fomes robustus.*
C–P–M–11–16	*Polyporus dryophilus.*
C–P–S–11	*Fomes robustus.*
D–O–F–8–10	*Poria cocos.*
D–P–I–11	*Irpex cinnamomeus.*
E–O–F–8–10	*Poria cocos.*
E–O–I–2–10	*Polyporus sulphureus.*
E–O–M–2–10	*Polyporus sulphureus.*
E–O–M–11–16	*Stereum subpileatum.*
E–O–M–11–16	*Stereum frustulosum.*
E–O–S–1–2–11–14	*Fistulina hepatica.*
E–P–F–1–2–10–16	*Merulius tremellosus.*
E–P–I–1–2–7–11	*Polyporus graveolens.*
E–P–I–1–2–11	*Polyporus croceus.*
E–P–M–11–16	*Stereum subpileatum.*
F–P–I–1–11	*Polyporus pargamenus.*
F–P–M–8–11–16	*Ustulina vulgaris.*

DESCRIPTIONS OF OAK-DECAYING FUNGI IN CULTURE

ARMILLARIA MELLEA Vahl ex Fr.

(Pl. 1, *A;* fig. 3, *A.*)

KEY PATTERN.—B–P–S–8–11–16 and B–P–V–8–11–16.

GROWTH CHARACTERISTICS.—Growth slow, forming a mat 1.5 to 2.5 cm. in diameter in 14 days; mat appressed, with a faintly white to "light buff," fine woolly or downy, superficial mycelium; mat proper under superficial covering, usually compacted, sometimes crusty, "hair brown;" most isolates showing few to numerous rhizomorphs in the agar under mat; occasional isolates, especially if much of the old staled agar was left on the inoculum, remained thin, with little surface mycelium, did not form rhizomorphs, and stained the agar dark brown; such isolates if freed from staled agar often developed normal surface mats and also produced rhizomorphs; margin narrow, even, or in staled forms, irregular; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–4(–5μ)μ[11] diameter, thin-walled, without clamps, much septate; nonstaining hyphae 1μ–3μ diameter, fibrous, brown or hyaline, smooth or with minutely roughened walls; hyphal chains composed of large, staining, thin-walled, short cells, 8μ–12μ diameter common in the center of rhizomorphs; cuticular cells thin-walled, hyaline or yellow, forming compacted areas, abundant in 7-day-old cultures, more difficult to demonstrate in 14 days.

TEMPERATURE RELATIONS.—Optimum approximately 25° C. Average mat diameters in 7 days in dark at constant temperatures follow: 1.2 cm., 20°; 1.5 cm., 25°; 1.0 cm., 30°; 0, 35°.

TEST-TUBE CULTURES.—In 28 days mat on slant and also on upper part of agar cylinder usually closely appressed, crusty, with little or no aerial mycelium, "haematite red," "burnt umber" to almost black, either smooth and glossy or covered with short downy hyphae; mat surrounding crusty center usually white, fine woolly on agar cylinder;

[11] Throughout bulletin numbers in parentheses, e. g. (–5), indicate extreme ranges.

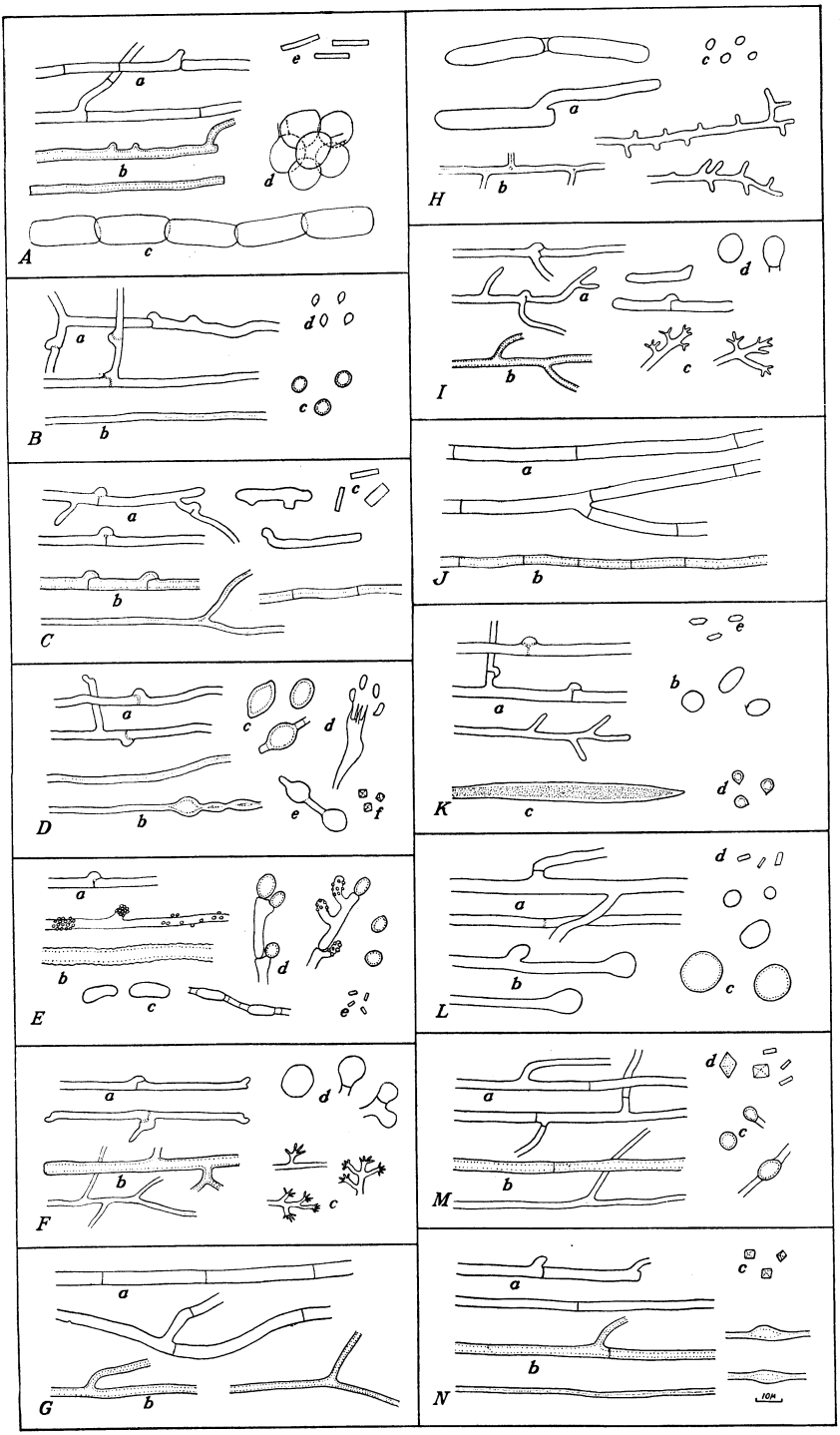

FIGURE 3.—For explanatory legend see opposite page.

few to many rhizomorphs, penetrating agar and on reaching surface forming small patches resembling miniature mats with appressed, dark centers and white woolly margins.

TYPE OF DECAY.—Soft white root rot and at times a white heart rot in the base of oaks, usually with fine black lines. Ninety-six isolations.

REMARKS.—*Armillaria mellea* is readily recognized by its slow-growing, reddish-brown, crusty mat and the production of rhizomorphs which ramify through the agar under the mat.

CORTICIUM LIVIDUM Pers. ex Fr.

(Pl. 1, *B*; fig. 3, *B*.)

KEY PATTERN.—B–P–I–1–2–5–6–11–16.

GROWTH CHARACTERISTICS.—Growth moderately rapid, forming in 7 days a mat 7 to 9 cm. in diameter; in 5 days with a white or somewhat yellowish velvety or fine woolly, restricted, indefinite, appressed central zone, and a wide, colorless, very thin, appressed cottony marginal zone; in 7 days the central zone becomes more extensive until in 9 to 14 days the entire mat is homogeneous, appressed, velvety or woolly.

In 14 days mat faintly white to chalky white, appressed, velvety or woolly, with crusty, compacted areas, "mustard yellow" to "primuline yellow," either confined to the center or scattered in irregular patches over the surface; yellow mycelium turning "purple" when touched with KOH solution; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–$6(-8\mu)\mu$ diameter, with clamps; nonstaining hyphae 2μ–4μ diameter, fibrous, hyaline or yellowish; small ovoid budlike branches which develop into globose chlamydospores 6μ–9μ diameter, abundant or rare; immature basidia usually present in 14 days; basidiospores common in cultures 3 to 4 weeks old, ovoid or ellipsoid, 4μ–$5\mu \times 2\mu$–2.5μ.

TEMPERATURE RELATIONS.—Optimum approximately 30° C.

TEST-TUBE CULTURES.—In 28 days mat on slant white or yellowish, appressed felty, with a bright yellow area about the inoculum, and occasionally developing a flat hymenial surface on the upper part of the slant; on agar cylinder mat white or yellow, thin, felted.

FIGURE 3.—*A*, *Armillaria mellea: a*, staining hyphae; *b*, nonstaining hyphae; *c*, short-celled hypha from rhizomorph; *d*, cuticular cells; *e*, crystals. *B*, *Corticium lividum: a*, staining hyphae; *b*, nonstaining hypha; *c*, chlamydospores; *d*, basidiospores. *C*, *Daedalea confragosa: a*, staining hyphae; *b*, nonstaining hyphae; *c*, crystals. *D*, *D. quercina: a*, staining hyphae; *b*, nonstaining hyphae; *c*, chlamydospores; *d*, basidium and basidiospores; *e;* swollen cells from test-tube cultures; *f*, crystals. *E*, *Fistulina hepatica: a*, staining hyphae; *b*, nonstaining hypha; *c*, chlamydospores from submerged hyphae; *d*, chlamydospores from aerial hyphae; *e*, crystals. *F*, *Fomes applanatus: a*, staining hyphae; *b*, nonstaining hyphae; *c*, staghorn branches; *d*, cuticular cells. *G*, *F. everhartii: a*, staining hyphae; *b*, nonstaining hyphae. *H*, *F. geotropus: a*, staining hyphae; *b*, nonstaining hypha; *c*, basidiospores. *I*, *F. lobatus: a*, staining hyphae; *b*, nonstaining hypha; *c*, staghorn branches; *d*, cuticular cells. *J*, *F. robustus: a*, staining hyphae; *b*, nonstaining hypha. *K*, *Hydnum erinaceus: a*, staining hyphae; *b*, chlamydospores; *c*, yellowish conducting organs from hymenium; *d*, basidiospores; *e*, crystals. *L*, *H. septentrionale: a*, staining hyphae; *b*, swollen hyphal tips; *c*, chlamydospores; *d*, crystals. *M*, *Hymenochaete rubiginosa: a*, staining hyphae; *b*, nonstaining hyphae; *c*, chlamydospores; *d*, crystals. *N*, *Irpex cinnamomeus: a*, staining hyphae; *b*, nonstaining hyphae; *c*, crystals.

TYPE OF DECAY.—A white sap and heart rot in connection with fire wounds. Twenty-seven isolations.

REMARKS.—Hepting (*18*) isolated this fungus from fire-damaged oaks in Louisiana and listed it as "yellow hymenomycete." The fungus can be readily identified in culture by the "purple" color imparted to the yellow mycelium by KOH solution.

DAEDALEA CONFRAGOSA Bolt. ex Fr.

(Fig. 3, *C*.)

KEY PATTERN.—B–P–I–1–11 and B–P–M–1–11.

GROWTH CHARACTERISTICS.—Growth moderately rapid or medium, forming in 14 days a mat 7 to over 9 cm. in diameter; mat at first white, in 7 days with a "cinnamon-buff" to "sayal brown" central zone and a white, appressed, velvety or fine woolly marginal zone.

In 14 days mat appressed, tough, velvety or felty, usually without aerial mycelium, adherent, forming a thick gelatinous film on the agar, either with a restricted or extensive "cinnamon-buff" to "buckthorn brown" central zone and a "pale ochraceous-buff" to "ochraceous-buff" marginal zone; or lacking the central zone and then the entire mat "pale ochraceous-salmon" to "ochraceous-buff;" odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–5μ diameter, with many clamps, in 14-day-old cultures broken up into short sections; nonstaining hyphae 1μ–4μ diameter, hyaline or yellow, either with clamps or much septated.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 6 days in dark at constant temperatures follow: 5.0 cm., 20°; 6.7 cm., 25°; 7.7 cm., 30°; 6.8 cm., 35°; 1.0 cm., 41°.

TEST-TUBE CULTURES.—In 28 days mat on slant appressed felty, often pulverulent, without aerial mycelium, "light ochraceous-buff" to "ochraceous-tawny" and "cinnamon-brown," margins in contact with glass often inrolled by crystalline material which collects between the mat and the tube; on agar cylinder white to "light buff," often yellowish from crystalline material which forms slender papillae against the tube; appressed dark-colored mat on slant usually sharply delimited from lighter colored mat on agar cylinder.

TYPE OF DECAY.—White sap rot.

REMARKS.—*Daedalea confragosa* resembles *Polyporus graveolens* somewhat in culture but may be readily separated by its tougher, gelatinous mat and by the lack of blunt-pointed setal hyphae which are found in the latter. Temperature relations can also be used to separate the two as *D. confragosa* has a higher optimum and will grow at 35° and 41° C.

DAEDALEA QUERCINA L. ex Fr.

(Pl. 1, *C*; fig. 3, *D*.)

KEY PATTERN.—A–O–M–1–2–11 and A–O–M–1–2–5–6–11.

GROWTH CHARACTERISTICS.—Growth medium, forming in 7 days a mat 4 to 5 cm. in diameter, white, homogeneous, usually faintly zonate, somewhat appressed, radiating short cottony or silky; margin white, cottony, even.

In 14 days mat 8 to 9 cm. in diameter, white, obscurely to strongly zoned, moderately appressed, compact, free, woolly or radiating short cottony, often floccose or nodulose particularly about center; odor slight, variable, not readily defined; oxidase test negative.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–5(–6)μ diameter, much branched, clamps numerous; nonstaining hyphae 1μ–4(–6)μ diameter, smooth, with thick hyaline walls, at times with swollen bulbous places, chlamydospores 8μ–20μ × 8μ–12μ, few, mostly ellipsoid, when mature with a hyaline wall 1μ–3μ thick; immature basidia common in 14 days in nodulose areas; basidiospores short cylindric, 5μ–7μ×2μ–4μ, not common before 21 to 30 days, not produced by all isolates; thin-walled, swollen, globose cells, staining with erythrosin, either single or in chains, usually common in fragile, "cinnamon-buff" mycelium from upper part of slant in test-tube cultures 6 to 8 weeks old.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in dark in 7 days at constant temperatures follow: 3.3 cm., 20°; 5.3 cm., 25°; 6.1 cm., 30°; 2.3 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant white, cottony to woolly, loose, nodulose, rather fragile, forming a definite mound, free; on agar cylinder white, fragile, woolly or cottony, homogeneous.

In 6 to 8 weeks mat on slant, raised, nodulose, fine woolly, fragile, free, "pinkish buff" to "cinnamon-buff," no sign of pores, and often containing thin-walled, swollen, deeply staining cells.

TYPE OF DECAY.—Brown sap and heart rot. Ten isolations.

REMARKS.—*Daedalea quercina* is difficult to separate from *Polyporus spraguei* in pure culture. The former often fruits in Petri dishes and the short cylindric basidiospores are characteristic. The two species may best be separated in 6- to 8-week-old test-tube cultures, as *D. quercina* forms a fragile, fine woolly, nodulose mat on the upper part of the slant, never with any indication of pores, and *P. spraguei* forms tough, felted, and faintly poroid areas composed of a dense mass of hyaline, fibrous hyphae. *P. spraguei* has not been observed to form basidiospores in culture.

FISTULINA HEPATICA Huds. ex Fr.

(Pl. 1, *D;* fig. 3, *E.*)

KEY PATTERN.—B–O–S–1–2–11–14 and E–O–S–1–2–11–14.

GROWTH CHARACTERISTICS.—Growth slow, forming in 14 days a mat 4–5 cm. in diameter; center either raised or depressed, cottony, white, "cream color," "naples yellow" or "pale pinkish cinnamon," sometimes with "light vinaceous-cinnamon" punctate areas; rest of mat white, cottony or woolly, raised, free, fragile, with a definite gelatinous layer on agar surface; margin proper appressed, colorless, cottony, slightly fimbriate; odorless; negative oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–5μ diameter, with clamps; nonstaining hyphae 2μ–5μ diameter, hyaline or yellowish, often with much roughened walls; surface hyphae from center with much fine, granular, yellowish, crystalline material, either incrusting the hyphae or bunched on short branches; chlamydospores of two kinds, those on aerial hyphae often with a brownish wall, ovoid or ellipsoid,

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3μ–12μ×3μ–7μ, those from submerged hyphae hyaline, nonstaining, irregular in shape, 8μ–25μ×4μ–10μ.

TEMPERATURE RELATIONS.—Optimum approximately 25° C. Average mat diameters in 7 days in dark at constant temperatures follow: 1.7 cm., 20°; 2.1 cm., 25°; 1.0 cm., 31°; 0, 35°.

TEST-TUBE CULTURES.—In 28 days mat on slant raised, loose or compacted, woolly, white; hard, compact, round nodules, white or with "daphne red" dots, occasionally with pinkish or reddish exudation drops, common on slant, and at times formed against the glass at lower part of slant and then much flattened and distorted by pressure; on agar cylinder white, woolly, fragile, adherent.

TYPE OF DECAY.—Wood infected by *Fistulina hepatica* becomes reddish brown, remaining firm without much evident decay, according to Cartwright (*8*) and Davidson.[12] Seventy-one isolations.

REMARKS.—*F. hepatica* may be recognized in culture by its slow-growing, at first white then yellowish or pinkish mat; the hard, rounded, pink- or red-dotted nodules which form in old cultures; and by its distinctive microscopic structure.

Rothberg (*35*) isolated the fungus from decayed jarrah (*Eucalyptus marginata* Sm.) and described cultural characteristics in detail.

FOMES APPLANATUS Pers. ex Gill.

(Pl. 1, *E;* fig. 3, *F.*)

KEY PATTERN.—A–P–M–1–8–9–11.

GROWTH CHARACTERISTICS.—Growth medium, forming in 14 days a mat 6 to 8 cm. in diameter; mat usually with a definite or indefinite white, appressed, pulverulent to downy, tough, adherent central zone, at times wrinkling the agar; marginal zone appressed, zonate, thin, downy, colorless or white, rarely somewhat cottony; margin proper appressed, colorless, even; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–5μ diameter, clamps numerous, in old cultures broken up into irregular lengths; nonstaining hyphae 1μ–5μ, mostly 1μ–3μ diameter, hyaline, smooth, fibrous; both submerged and superficial hyphae bearing numerous staghorn branches, difficult to find in compacted areas but easily demonstrated in marginal zone; hyaline or staining cuticular cells few to many, mostly in central zone.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C.

TEST-TUBE CULTURES.—Mat in 4 to 8 weeks compacted, appressed, usually wrinkled, as dark as "mouse gray" and "quaker drab," with much yellowish crystalline material on agar cylinder.

TYPE OF DECAY.—White sap and heart rot. Four isolations.

REMARKS.—For other accounts of pure-culture studies with this fungus see Campbell (*5*), Fritz (*14*), and White (*42*).

The fungus is easily recognized by its appressed, pulverulent mat, which wrinkles the agar and has staghorn branches and cuticular cells.

[12] DAVIDSON, ROSS W. FOREST PATHOLOGY NOTES. 2. FISTULINA HEPATICA CAUSING "BROWN OAK." U. S. Dept. Agr. Plant Dis. Rptr. 19: 95–96. 1935. [Mimeographed.]

FOMES EVERHARTII (Ell. and Gall.) Schrenk

(Pl. 1, *F;* fig. 3, *G.*)

KEY PATTERN.—C–P–M–11.

GROWTH CHARACTERISTICS.—Growth medium, forming in 14 days a mat 4.5 to 7 cm. in diameter, surface mycelium usually thin, silky cottony or fine woolly, fragile, "cream color," "naples yellow," and "ochraceous-buff," many times but not always with a greenish tinge; mat proper next to agar, compacted, fairly thick, adherent, friable, dark brown, color very noticeable from under side; certain isolations do not form dark-brown staled mats until more than 14 days old; margin white, cottony, even; no odor; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–6μ diameter, thin-walled, septated but without clamps, in staled areas gradually becoming yellow-walled, at first with staining content but finally entirely nonstaining, much septated; nonstaining fibrous hyphae mostly 2μ–4μ diameter, thick-walled, yellow or brown, smooth, sparsely septate.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 2.6 cm., 20°; 4.1 cm., 25°; 4.8 cm., 30°; 1.4 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant and agar cylinder usually with a silky-cottony, "antimony yellow" to "yellow ocher" superficial covering, and a brown mat proper, which forms a dark layer on the agar; superficial mycelium fading with age to "warm buff" and "honey yellow."

TYPE OF DECAY.—White heart rot (*16*). Seven isolations.

REMARKS.—The fungus is characterized by a silky-cottony superficial mycelium which usually has a greenish sheen in 14 days. The dark brown mat proper is also distinctive.

FOMES GEOTROPUS Cke.

(Pl. 1, *G;* fig. 3, *H.*)

KEY PATTERN.—A–P–F–5–6–11 and A–P–F–11.

GROWTH CHARACTERISTICS.—Growth rapid, completely filling Petri dish in 4 to 5 days; mat in 14 days thin, felty, surface appressed, downy or pulverulent, usually without aerial mycelium, white, azonate, adherent, often with lamellate sporophore tissue developing flat on the mat surface, either in continuous masses or in rosettelike groups; odor definitely fungoid; positive oxidase reaction; reaction slow, usually requiring from 7 to 14 days for definite results.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–8 (–10μ) μ diameter, septated, without clamps; in 14 days broken up into short lengths; nonstaining hyphae 1μ–3μ diameter, hyaline, smooth, few septations; basidiospores ellipsoid, 4μ–5μ $\times$ 3μ–4μ.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 3 days in dark at constant temperatures follow: 6.1 cm., 20°; 7.7 cm., 25°; 8.7 cm., 30°; 7.8 cm., 35°; 0 to 1.5 cm., 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant and agar cylinder, white, appressed, thin, felty, without aerial mycelium, usually with thin lamellate or coarsely poroid sporophores formed on tops and sides of slant.

TYPE OF DECAY.—White sap and heart rot (*18*). Twenty-nine isolations.

REMARKS.—All isolations of *Fomes geotropus* have been from Louisiana and Mississippi.

The fungus is readily separated from all others reported here by its appressed, felty, white mat and its fast rate of growth. The thin lamellate sporophores produced in cultures are also distinctive.

FOMES LOBATUS (Schw.) Cke.

(Pl. 1, *H;* fig. 3, *I.*)

KEY PATTERN.—B–P–I–1–8–9–11 and B–P–M–1–8–9–11.

GROWTH CHARACTERISTICS.—Growth moderately rapid or medium, forming a mat 8 to over 9 cm. in diameter in 14 days; mat at first white; in 14 days central zone restricted or extensive, indefinite, appressed, pulverulent or downy, tough, thin, adherent, often wrinkling the agar, "cream color," "antimony yellow," "strontian yellow" to "dark olive-buff" or "drab;" marginal zone appressed, downy to short cottony, white; odor mushroomlike or earthy; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–5μ diameter, with clamps, in 14 days broken up into irregular lengths; nonstaining hyphae 2μ–3μ diameter, without clamps, hyaline, fibrous, much branched; staghorn branches common on both superficial and submerged hyphae, easy to demonstrate in 7 days but usually obscured in 14 days; thin-walled, hyaline or yellowish cuticular cells, common or rare, in compacted central zone.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 5.1 cm., 20°; 7.3 cm., 25°; 7.2 cm., 30°; trace, 35°.

TEST-TUBE CULTURES.—In 28 days mat on slant appressed, compacted, rough, granular, pulverulent, at times wrinkled, yellowish to "cinnamon-drab;" on agar cylinder irregularly nodulose, cottony, often yellowed from granular masses containing crystalline material.

TYPE OF DECAY.—White heart rot.

REMARKS.—*Fomes lobatus* is closely related to *F. applanatus*, and this relationship is apparent from a consideration of the cultural characteristics of the two. However, the former usually produces a more vigorous mat with a pronounced yellow or brown central zone developing in 14 days.

FOMES ROBUSTUS Karst.

(Pl. 1, *I;* fig. 3, *J.*)

KEY PATTERN.—C–P–S–11 and C–P–M–11.

GROWTH CHARACTERISTICS.—Growth slow to medium, forming a mat 4 to 6 cm. in diameter in 14 days; mat moderately raised, compacted felty or felted woolly, faintly to strongly zonate, "warm buff" to "chamois" and "antimony yellow" with a narrow white, cottony or woolly, even margin; no odor; postive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–8μ diameter, thin-walled, without clamps, much septated especially in older portions; nonstaining hyphae either 2μ–8μ diameter with yellow walls and many septations or 2μ–5μ fibrous, smooth, sparsely septate, thick-walled.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 2.5 cm., 20°; 3.5 cm., 25°; 3.4 cm., 30°; trace, 35°.

TEST-TUBE CULTURES.—In 28 days mat on slant raised, forming a definite pad, tough, felty, free, "yellow ocher" to "buckthorn brown;" on agar cylinder homogeneous, felty, tough, free, "yellow ocher" to "buckthorn brown."

TYPE OF DECAY.—White heart rot. Three isolations from sporophores.

REMARKS.—This fungus and the closely related *Fomes calkinsii* (Murr.) Sacc. and D. Sacc. have been described in detail in culture by Campbell (*5*).

Sporophore isolations of *Fomes robustus* and *F. calkinsii* from oak appear identical and are treated here under the former name. *F. robustus* on oak is often mistaken for *F. igniarius* (L.) Gill. In this study no authentic case of *F. igniarius* on oak was found.

The fungus in culture is characterized by a slow-growing, regular, raised mat, mostly felted woolly in appearance, and solidly yellow with a narrow white margin.

HYDNUM ERINACEUS Bull. ex Fr.

(Pl. 1, *J;* fig. 3, *K.*)

KEY PATTERN.—A–P–M–1–2–10–16.

GROWTH CHARACTERISTICS.—Growth rather variable, medium, forming in 14 days a mat 5 to 9 cm. in diameter, white, usually thin, plumose or plumose cottony, with mycelium appressed to agar surface; or mycelium submerged for most part and forming a dark discolored zone in the agar; margin usually thin, colorless, very fimbriate; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—All hyphae staining 2μ–6μ diameter, with clamps; chlamydospores globose to ellipsoid, not abundant, 4$\mu\times$10μ; yellowish sharp-pointed swollen hyphae common in the hymenial layer of sporophores produced in culture, 6$\mu\times$10μ broad; basidiospores 4μ–6μ, globose, 1–guttulate.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 1.7 cm., 20°; 2.4 cm., 25°; 2.3 cm., 30°; 0 to trace, 35°.

TEST-TUBE CULTURES.—In 28 days mat white, appressed, plumose cottony, fragile, thin, with or without agar discolorations, usually producing corallike white fruiting masses in 4 to 8 weeks, and basidiospores in abundance.

TYPE OF DECAY.—White heart rot, which is usually a white piped or pocket rot in the incipient stages. One hundred and fifteen isolations.

REMARKS.—*Hydnum erinaceus* is readily recognized by its appressed, white, plumose mat and by the corallike sporophores formed in tube cultures.

HYDNUM SEPTENTRIONALE Fr.

(Pl. 1, *K;* fig. 3, *L.*)

KEY PATTERN.—A–P–M–2–10–16.

GROWTH CHARACTERISTICS.—Growth medium, forming in 14 days a mat 5 to 8 cm. in diameter, thin, appressed, azonate, homogeneous,

white, pulverulent to downy; margin colorless, wide, appressed, coarsely fimbriate; no odor; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—All hyphae staining, 2μ–5(–6μ)μ diameter, thin-walled, septate, no clamps; hyphae with swollen tips resembling immature basidia common and characteristic; chlamydospores few or many, 5μ–15μ, globose or ellipsoid.

TEMPERATURE RELATIONS.—Optimum approximately 25° C. Average mat diameters in 7 days in dark at constant temperatures follow: 3.8 cm., 20°; 6.0 cm., 25°; 4.8 cm., 30°; 0, 35°.

TEST-TUBE CULTURES.—In 28 days mat on slant, woolly to pulverulent, white, with somewhat raised pinkish areas on upper part; on agar cylinder floccose woolly, white.

TYPE OF DECAY.—White heart rot. Two isolations.

REMARKS.—*Hydnum septentrionale* is rather distinct in culture, producing a thin, white, appressed mat with a wide, coarse, fimbriate margin. The hyphae with swollen tips are characteristic and not formed by any other fungus reported here.

HYMENOCHAETE RUBIGINOSA Dicks. ex Lév.

(Pl. 1, *L;* fig. 3, *M.*)

KEY PATTERN.—B–P–S–11–17 and B–P–S–2–11–17.

GROWTH CHARACTERISTICS.—Growth slow, forming in 14 days a mat 3 to 4 cm. in diameter; mat at first white or colorless, gradually turning yellowish; the central zone in 14 days becomes extensive, fine woolly to compacted woolly, "chamois," "honey yellow," "pinkish cinnamon" to "cinnamon," not solidly one color; marginal zone narrow, white, appressed or raised; an occasional isolate remains white with only a suggestion of color about center; yellowish-green diffusion zone formed under mat, pronounced to rather indefinite; no odor; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–4(–5μ)μ diameter, thin-walled, without clamps, septate, grading into nonstaining yellow hyphae with thick walls and many septations; yellow fibrous hyphae 2μ–3μ diameter, sparsely septate, smooth; chlamydospores mostly globose, 4μ–10μ, common or entirely absent.

TEMPERATURE RELATIONS.—Optimum approximately 25° C. Average mat diameters in 7 days in dark at constant temperatures follow: 1.3 cm., 20°; 1.7 cm., 25°; trace, 31°; 0, 35°.

TEST-TUBE CULTURES.—In 28 days mat either thin or thick, white or "honey yellow" to "cinnamon" or "buckthorn brown," usually with a brown staled area showing through the superficial mycelium; most prominent feature the "olive-green" or "olive-yellow" color imparted to the agar by the fungus.

TYPE OF DECAY.—White pocket rot (*10, 23*). Three isolations.

REMARKS.—*Hymenochaete rubiginosa* is readily distinguished in culture by the "olive-green" or "olive-yellow" color which it imparts to the agar in Petri dishes and test tubes.

IRPEX CINNAMOMEUS Fr.

(Fig. 3, *N.*)

KEY PATTERN.—C–P–I–11 and D–P–I–11.

GROWTH CHARACTERISTICS.—Growth moderately rapid, forming a mat 5 to 6 cm. in diameter in 7 days; mat usually with a well-defined

central zone, "ochraceous-tawny," "buckthorn brown" or "cinnamon-brown" and a narrow or wide marginal zone, white or "straw yellow" to "naples yellow" or "mustard yellow;" margin proper white or yellowish, even or coarsely fimbriate.

In 14 days either solidly "buckthorn brown" to "dresden brown" and "saccardo's umber," or with a prominent brown central zone and a white or "warm buff" marginal zone; central zone of crisp, compacted, crusty mycelium; the crusty portion is often obscured by a thin, appressed downy or felty whitish superficial covering; white marginal zone appressed, thin, fragile, velvety or downy; no odor; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–5 (–6μ)μ diameter, thin-walled, septate, without clamps, grading into yellow, nonstaining, much-septated forms; fibrous yellow hyphae 2μ–5μ diameter, thick-walled, few septations, at times with swollen places.

TEMPERATURE RELATIONS.—Optimum 25° C. Average mat diameters in 7 days in dark at constant temperatures follow: 4.2 cm., 20°; 6.8 cm., 25°; 3.5 cm., 31°; trace, 35°.

TEST-TUBE CULTURES.—In 28 days mat on slant appressed, crusty, "honey yellow" and "clay color" to "olive-ocher" and "buckthorn brown," sharply separated from mat on agar cylinder by a raised brown line; on agar cylinder white, cottony.

TYPE OF DECAY.—White sap rot.

REMARKS.—*Irpex cinnamomeus* is readily recognized, especially in tube cultures, by its appressed, yellow or brown crusty mat, which is separated from the white, cottony portion on the agar cylinder by a raised brown line.

IRPEX MOLLIS Berk. and Curt.

KEY PATTERN.—A-P-I-1-2-11 and A-P-M-1-2-11.

(See *Polyporus obtusus*.)

LENTINUS TIGRINUS Bull. ex Fr.

(Fig. 4, *A*.)

KEY PATTERN.—B–P–F–1–2–11–17.

GROWTH CHARACTERISTICS.—Growth rapid, forming a mat over 9 cm. in diameter in 7 days; in 14 days mat appressed, felty, with little or no aerial mycelium, free or adherent, white or slightly "light buff" over entire surface or more often solidly or irregularly "snuff brown" to "cinnamon-brown," at times with a white central zone; immature sporophores appearing as short raised stalks occasionally develop in 14 days; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–5μ diameter, with many clamps, in older cultures broken up into short, irregular lengths; nonstaining hyphae 1μ–5μ diameter, either hyaline, fibrous, much-curled, or brown, smooth, straight; chlamydospores few to many, 8μ–15μ×8μ–12μ, ovoid or ellipsoid, with a definite hyaline wall; basidiospores from sporophores produced in tube cultures, oblong, 7μ–9μ×2μ–3μ.

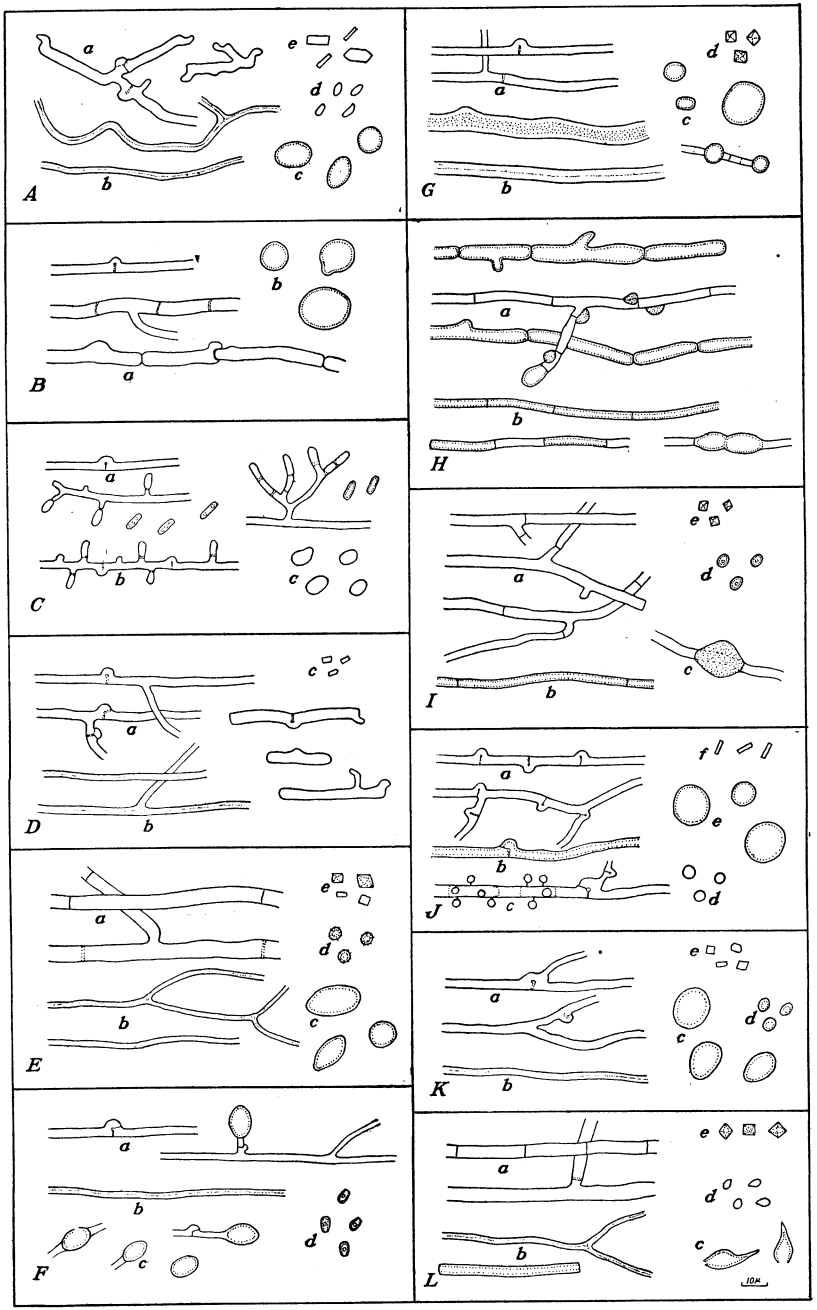

FIGURE 4.—For explanatory legend see opposite page.

TEMPERATURE RELATIONS.—Optimum 35° C. Average mat diameters in 3 days in the dark at constant temperatures follow: 3.1 cm., 20°; 4.6 cm., 25°; 7.0 cm., 30°; 7.7 cm., 35°; 1.0 cm., 41°.

TEST-TUBE CULTURES.—In 28 days mat on slant appressed, felty, rather friable, not definitely free, white or more generally "ochraceous-buff" to "cinnamon-brown;" on agar cylinder white, felty, free; usually producing a single long stiped, normal-appearing sporophore in 28 days, but occasionally requiring 6 to 8 weeks.

TYPE OF DECAY.—White sap and heart rot (*18*). Twelve isolations.

REMARKS.—In Petri-dish cultures the fungus forms a felty, appressed mat, which usually lacks aerial mycelium and is white or brownish. The optimum temperature, 35° C., is higher than most other fungi in the "B" group of fast growers. The formation of typical *Lentinus* sporophores in test tubes is also a distinctive feature.

MERULIUS TREMELLOSUS Schrad. ex Fr.

(Pl. 1, *M;* fig. 4, *B.*)

KEY PATTERN.—E–P–F–1–2–10–16.

GROWTH CHARACTERISTICS.—Growth rapid, forming a mat 9 cm. in diameter in 5 or 6 days; thin, colorless, closely appressed with a coarse fimbriate margin; in 7 days mat faintly white or gray, fragile, thin, appressed, fine woolly to floccose woolly, azonate.

In 14 days mat usually "tilleul buff" to "pinkish buff," fragile, azonate, appressed, fine woolly to somewhat tufted or floccose cottony; buff surface mycelium turning KOH solution red on contact with it; no definite odor; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—No distinction between submerged and superficial hyphae, both 2μ–$5(-7)\mu$ diameter, staining, clamps common, occasionally much septate; thick, short cells common in older portions of the mat; chlamydospores few to many, typically globose, 9μ–25μ in diameter, with thin hyaline wall.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average diameters of mats in dark in 5 days at constant temperatures follow: 3.5 cm., 20°; 7.5 cm., 25°; 9.0 cm., 30°; 4.5 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat white on agar cylinder, woolly or cottony on slant, with "avellaneous" to "wood brown" feathery mycelium on glass opposite slant and also on slant proper.

TYPE OF DECAY.—White sap and heart rot. Eleven isolations.

FIGURE 4.—*A, Lentinus tigrinus: a,* staining hyphae; *b,* nonstaining hyphae; *c,* chlamydospores; *d,* basidiospores; *e,* crystals. *B, Merulius tremellosus: a,* staining hyphae; *b,* chlamydospores. *C, Pholiota adiposa: a,* staining hypha; *b,* conidiophores and conidia; *c,* chlamydospores. *D, Pleurotus ostreatus: a,* staining hyphae; *b,* nonstaining hyphae; *c,* crystals *E, Polyporus berkeleyi: a,* staining hyphae; *b,* nonstaining hyphae; *c,* chlamydospores; *d,* basidiospores; *e,* crystals. *F, P. compactus: a,* staining hyphae; *b,* nonstaining hypha; *c,* chlamydospores; *d,* basidiospores. *G, P. croceus: a,* staining hyphae; *b,* nonstaining hyphae; *c,* chlamydospores; *d,* crystals. *H, P. dryadeus: a,* staining hyphae; *b,* nonstaining hyphae. *I, P. dryophilus: a,* staining hyphae; *b,* nonstaining hypha; *c,* resinous mass on hypha; *d,* basidiospores; *e,* crystals. *J, P. fissilis: a,* staining hyphae; *b,* nonstaining hypha; *c,* conidiophore; *d,* conidia; *e,* chlamydospores; *f,* crystals. *K, P. frondosus: a,* staining hyphae; *b,* nonstaining hypha; *c,* chlamydospores; *d,* basidiospores; *e,* crystals. *L, P. gilvus; a,* staining hyphae; *b,* nonstaining hyphae; *c,* bulbous setae; *d,* basidiospores; *e,* crystals.

REMARKS.—*Merulius tremellosus* is usually not considered as a heart-rotting organism. However, it has been isolated repeatedly from the heartwood of living oak trees in connection with fire wounds and other basal injuries. Hepting (*18*) found it associated with decay following fire injury and listed it as an unidentified white hymenomycete. Vanin (*38*) described it in culture and noted the red reaction with KOH.

M. tremellosus in Petri-dish culture is characterized by its appressed mat, which is colorless during the first few days of growth, and by its definite buff color in 14 days. In test tubes the "avellaneous" to "wood brown," feathery mycelium, which develops over the slant and clings to the glass of the test tube, is very distinctive. The red color that the buff mycelium imparts to KOH is also characteristic.

PHOLIOTA ADIPOSA Batsch ex Fr.

(Pl. 1, *N;* fig. 4, *C.*)

KEY PATTERN.—B–P–M–1–2–3–10–17.

GROWTH CHARACTERISTICS.—Growth medium, forming in 14 days a mat 6 to 9 cm. in diameter; fine woolly or floccose cottony about center to short cottony at margins, azonate or more generally faintly to strongly zoned, free, fragile; most of mat "cream color" with a narrow to wide white marginal zone; margin proper white cottony, fairly even; no odor; positive oxidase reaction.

In 6 to 8 weeks most isolations form diminutive sporophores about the margins of the dish. Sporophores yellowish with scaly tops and stems, closely resembling those produced in nature.

HYPHAL CHARACTERISTICS.—Hyphae all staining, 2μ–5μ diameter with clamps, chlamydospores few to many, ellipsoid to short cylindric 5μ–10μ×4μ–9μ; conidia very abundant, mostly 6μ–15μ×2μ–4μ, usually produced on definite conidiophores or on the sides of simple hyphae, in older cultures often becoming thick-walled, yellow, entire surface hyphae at times covered with conidia.

TEMPERATURE RELATIONS.—Optimum approximately 25° C. Average mat diameters in 7 days in dark at constant temperatures follow: 4.2 cm., 20°; 5.2 cm., 25°; 2.6 cm., 30°; 0, 35°.

TEST-TUBE CULTURES.—In 28 days forming on slant compacted "warm buff" to "yellow ocher" nodulose areas which often develop, especially in 6 to 8 weeks, into well-formed, miniature sporophores; rest of mat on slant compacted cottony or woolly; on agar cylinder cottony, zoned, white or "cream color" to "ochraceous-buff," often with nodulose patches.

TYPE OF DECAY.—White heart rot. Three isolations.

REMARKS.—*Pholiota adiposa* is readily recognized in culture, because it usually forms in 6 to 8 weeks well-developed, typical, although miniature, sporophores; the abundant conidia are also distinctive.

PLEUROTUS OSTREATUS Jacq. ex Fr.

(Pl. 1, *O;* fig. 4, *D.*)

KEY PATTERN.—A–P–I–1–11–17.

GROWTH CHARACTERISTICS.—Growth moderately rapid, forming in 7 days a mat 6 to 8 cm. in diameter; in 14 days mat white, matted or slightly appressed, cottony to floccose cottony, with a loose cottony

margin, fragile, often definitely zonate, adherent; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–5 (–7μ) μ diameter, thin-walled, many clamps, in 14 days broken up into short lengths; nonstaining hyphae 1μ–3 (–5μ) μ diameter, fibrous, hyaline, no clamps.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 6 days in dark at constant temperatures follow: 5.2 cm., 20°; 7.2 cm., 25°; 7.8 cm., 30°; 4.2 cm., 35°; 0, 41°.

TEST-TUBE CULTURES.—In 28 days mat on slant and agar cylinder white, felted cottony, often with abortive sporophores in small clusters, the latter not common until 6 to 8 weeks. Sporophores always abortive with short stalks and only a suggestion of a pileus.

TYPE OF DECAY.—White rot of sapwood and heartwood. Five isolations.

REMARKS.—*Pleurotus ostreatus* is readily recognized in test-tube cultures 6 to 8 weeks old by the small abortive sporophores produced in clusters on the slant and agar cylinder.

POLYPORUS BERKELEYI Fr.

(Pl. 2, *A;* fig. 4, *E.*)

KEY PATTERN.—A–P–M–2–5–6–11.

GROWTH CHARACTERISTICS.—Growth medium, forming in 14 days a mat 5 to 8 cm. in diameter, closely appressed, pulverulent to floccose downy, sometimes with scant aerial hyphae, azonate, fragile or compacted, tough, free, white; margin appressed, colorless, even; odor pronounced, sweetish; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–6 (–7μ) μ diameter, without clamps, septate, thin-walled; nonstaining hyphae 1μ–2μ diameter, fibrous, hyaline, smooth; chlamydospores usually abundant, subglobose to ellipsoid, 7μ–25μ×5μ–12μ; basidia produced on surface of mat, usually common in 14 days; basidiospores 5μ × 7μ, echinulate, globose, 1-guttulate.

TEMPERATURE RELATIONS.—Optimum approximately 25° C. Average diameter of mat in 7 days in the dark at constant temperatures follow: 3.6 cm., 20°; 4.7 cm., 25°; 0 to trace, 31°.

TEST-TUBE CULTURES.—In 28 days mat on slant, raised, loose or compacted, woolly, tough, free, white or faintly yellow; on agar cylinder, woolly or felty, tough, free, white.

TYPE OF DECAY.—White string and ray rot described in detail by Long (*23*). Eleven isolations.

REMARKS.—*Polyporus berkeleyi* is readily recognized in culture by its characteristic odor and by the echinulate basidiospores produced on basidia attached directly to the mat surface without any evidence of a sporophore.

POLYPORUS COMPACTUS Overh.

(Pl. 2, *B;* fig. 4, *F.*)

KEY PATTERN.—A–P–I–1–2–11 and A–P–I–1–2–5–6–11.

GROWTH CHARACTERISTICS.—Growth moderately rapid, forming a mat 6 to 7 cm. in diameter in 7 days; in 14 days mat white, appressed, compacted, tough, thin felty, free, usually with nodulose patches and yellowish, guttulate, abortive poroid areas either scattered or forming

a wide circle about the center, these areas composed of dense masses of chlamydospores and only occasionally producing basidia and basidiospores; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–5μ diameter, with prominent clamps; nonstaining hyphae 2μ–3μ diameter, fibrous, hyaline, not abundant from compacted central portion; chlamydospores ellipsoid to barrel-shaped, 9μ–12μ × 6μ–9μ, very abundant, when immature clamp connection with hyphae very noticeable; basidiospores rare, hyaline, truncate, 6μ–9μ × 4μ–6μ; narrow paraphyses present in hymenial layer.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in dark in 6 days at constant temperatures follow: 2.0 cm., 20°; 5.0 cm., 25°; 9.0 cm., 30°; trace, 35°; no growth, 40°.

TEST-TUBE CULTURES.—In 28 days, white with abundant yellowish, cheesy, imperfect pores on slant, occasionally with feathery mycelium on glass opposite slant. Poroid areas a mass of chlamydospores with basidia and basidiospores of rare occurrence.

TYPE OF DECAY.—White heart rot. Fifty-five isolations.

REMARKS.—Many of the peculiarities of the sporophore of *Polyporus compactus* can be demonstrated in pure culture. According to Overholts (*30*) it is usually entirely resupinate, only rarely developing a typical pileus and composed of a mass of chlamydospores. Pores are poorly formed and basidia and basidiospores are difficult to locate. In culture, abortive yellowish poroid areas develop in both Petri dishes and test tubes. This poroid tissue is composed of masses of chlamydospores identical in size and shape with those found in the normal sporophore.

POLYPORUS CROCEUS Pers. ex Fr.

(Pl. 2, *C;* fig. 4, *G.*)

KEY PATTERN.—E–P–I–1–2–11.

GROWTH CHARACTERISTICS.—Growth moderately rapid, forming in 7 days a mat 4 to 6 cm. in diameter; in 14 days center usually raised, woolly, fairly distinct, "pale yellow-orange," "orange-buff" to "ochraceous-orange;" rest of mat appressed, thin, adherent, forming a thick gelatinous cover, azonate, white or more commonly "pinkish buff" to "light ochraceous-buff" with color more pronounced at center and fading to white at the margin; margin proper appressed, white cottony, fairly even; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–7μ diameter, few clamps, septations common; nonstaining hyphae 2μ–7μ diameter, either entirely hyaline with thick walls or thick-walled with a narrow thread of staining contents; chlamydospores common, 5μ × 18μ, mostly globose, subglobose or ellipsoid, with a definite hyaline wall.

TEMPERATURE RELATIONS.—Optimum approximately 31°C. Average mat diameters in 7 days in dark at constant temperatures follow: 2.5 cm., 20°; 4.7 cm., 25°; 6.8 cm., 31°; 3.6 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant raised, loosely cottony, often with feathery mycelium on glass opposite slant, tough, adherent, "pale pinkish buff," "pale cinnamon-pink" to "light vinaceous-cinnamon" and "pinkish cinnamon;" on agar cylinder compacted woolly to felty, "pale pinkish cinnamon" to "pinkish cinnamon" or white in spots, homogeneous.

TYPE OF DECAY.—White piped rot described by Long (*23*). Four isolations.

REMARKS.—*Polyporus croceus* is recognized in culture by its pinkish mat, which forms a tough gelatinous film on the agar. The thick-walled hyphae with a narrow thread of staining content is also characteristic.

POLYPORUS DRYADEUS Pers. ex Fr.

(Pl. 2, *D*; fig. 4, *H*.)

KEY PATTERN.—B–P–V–11–16.

GROWTH CHARACTERISTICS.—Growth very slow, mat in 7 days confined mostly to inoculum; in 14 days 1 to 2 cm. in diameter, superficial mycelium appressed, downy or velvety, colorless, pale white or somewhat yellowish; mat proper thick, friable, dark brown, usually obscured by the light superficial mycelium, margin narrow to wide, colorless, even, closely appressed; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae from advancing margin, 2μ–6(–8μ)μ diameter, thin-walled, without clamps, often with many empty cells; hyphae from compacted mat proper irregular in diameter, 3μ–6 (–8μ)μ diameter, yellow or brown, much septated, usually constricted at the septa, with terminal or intercalary swollen cells and often with many globose or irregular resinous masses; fibrous superficial hyphae 2μ–5μ, yellow, moderately thick-walled, much septated.

TEMPERATURE RELATIONS.—Optimum approximately 25° C. Average mat diameters in 7 days in dark at constant temperatures follow: 1.2 cm., 20°; 1.5 cm., 25°; trace, 31°; 0, 35°.

TEST-TUBE CULTURES.—In 28 days mat 2 to 3 cm. long, much appressed, with dark-brown agar discoloration under mat; mat proper compacted, thick, friable, "buckthorn brown" to "sayal brown," and "tawny-olive" or rarely "antimony yellow," usually with a fine woolly or downy superficial covering.

TYPE OF DECAY.—White sap and heart rot in the roots and in the bases of oaks (*10*, *24*). Five isolations.

REMARKS.—The fungus is distinct in culture and is easily recognized by its very slow rate of growth, by the agar discoloration so prominent in test tubes, and by its distinctive hyphae.

POLYPORUS DRYOPHILUS Berk.

(Pl. 2, *E*; fig. 4, *I*.)

KEY PATTERN.—C–P–M–11–16.

GROWTH CHARACTERISTICS.—Growth medium, forming in 14 days a mat 8 to 9 cm. in diameter, raised, silky to silky cottony, fragile, often with a depressed center, azonate or obscurely zoned, somewhat adherent, "naphthalene yellow," "cream color" to "naples yellow" and "warm buff;" margin usually white, silky, even; odorless; positive oxidase reaction on tannic acid medium and developing poroid areas which produce mature basidiospores in 14 to 21 days.

Five-percent KOH solution dropped on mat surface stimulates growth and causes the formation of raised, compacted mounds which in 7 to 14 days often touch the Petri-dish cover.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–7μ diameter, without clamps, thin-walled, fragile, septate, grading gradually into moderately thick-walled, nonstaining forms; nonstaining hyphae 2μ–3(–4μ)μ diameter, thick-walled, yellow or brown, smooth, septate; resinous masses often formed on staining and nonstaining hyphae; basidiospores ellipsoid, brown, 5μ–7μ × 4μ–6μ, produced only on mats grown on tannic acid medium.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 3.7 cm., 20°; 5.4 cm., 25°; 6.2 cm., 30°; 4.6 cm., 35°; trace, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant raised, loose or somewhat compacted, woolly, forming a definite pad, top "cream color" to "warm buff," sides "ochraceous-buff" to "antimony yellow" streaked with "ochraceous-tawny;" on agar cylinder felty, tough, free, solidly "antimony yellow" or "yellow ocher," or with margins and alternating bands "ochraceous-tawny" to "cinnamon-brown."

TYPE OF DECAY.—White piped rot (*17*). Fifty-one isolations.

REMARKS.—Vanin (*38*) described a fungus in culture which he called *Polyporus dryophilus* from oaks in Russia. His illustrations showed numerous clamps, chlamydospores and oidia. The fungus that he described is evidently not the one treated here as *P. dryophilus*.

Polyporus dryophilus is fairly easy to recognize by its silky or silky-cottony, loose, light-yellow mat and by sporophore formation on tannic acid medium. *P. hispidus* resembles it macroscopically, but the possession of setal hyphae by the former readily separates the two. No other fungus was stimulated by KOH solution dropped on the surface as was *P. dryophilus*.

POLYPORUS FISSILIS Berk. and Curt.

(Pl. 2, *F;* fig. 4, *J.*)

KEY PATTERN.—A–P–F–1–2–3–11.

GROWTH CHARACTERISTICS.—Growth rapid, forming a mat over 9 cm. in diameter in 7 days; in 14 days mat fine woolly, white, either free or adherent, forming a milky layer on the agar, azonate, usually with a raised white to faintly "cream color," plumose or cottony area about the center; odor faint, not distinctive; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–5μ diameter, many clamps, mostly thin-walled but some with thick hyaline walls and a narrow thread of deep staining content; incrusted hyphae common; nonstaining hyphae 1μ–5μ diameter, hyaline; chlamydospores mostly globose 5μ–20μ, with definite hyaline wall; conidia 1μ–4μ, abundant, borne on short sterigmata on ordinary hyphae.

TEMPERATURE RELATIONS.—Optimum approximately 31° C. Average mat diameters in 5 days in the dark at constant temperatures follow: 2.5 cm., 20°; 4.9 cm., 25°; 8.3 cm., 31°; 6.2 cm., 35°; 0, 41°.

TEST-TUBE CULTURES.—In 28 days mat on slant forming a raised, convex pad, loosely plumose cottony, very fragile, "sulphur yellow" to "primrose yellow;" on agar cylinder, fragile, nodulose or fine floccose woolly, usually white but occasionally yellowish, usually yellow of mat on slant rather sharply delimited from white portion on agar cylinder.

TYPE OF DECAY.—White soft heart rot (*31*). Eleven isolations.

REMARKS.—The most characteristic feature of *Polyporus fissilis* in culture is the abundant conidia produced on short sterigmata on ordinary hyphae.

POLYPORUS FRONDOSUS Dicks. ex Fr.

(Pl. 2, *G;* fig. 4, *K.*)

KEY PATTERN.—A–P–I–1–2–10–16 and A–P–M–1–2–10–16.

GROWTH CHARACTERISTICS.—Growth moderately rapid or medium, forming in 14 days a mat 8 to 9 cm. or more in diameter, fine woolly, appressed, homogeneous, azonate, fragile, free, usually white or colorless, at times slightly yellow about inoculum and at times with a yellowish discoloration of the agar under the mat; margin colorless, appressed, fairly even; odor at times that of carbide; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Submerged and superficial hyphae staining, 2μ–5μ diameter, with numerous clamps; fibrous, hyaline nonstaining hyphae 2μ–3μ diameter, only occasionally formed in 14 days; chlamydospores few to abundant, ovoid to ellipsoid, 6μ–20μ×6μ–10μ, when mature with a thick, hyaline wall; sporophores rarely formed in culture, basidiospores globose or subglobose, 4μ–6μ, 1-guttulate.

TEMPERATURE RELATIONS.—Optimum approximately 25° C. Average mat diameters in 7 days in dark at constant temperatures follow: 3.5 cm., 20°; 5.5 cm., 25°; 0 or trace, 31°.

TEST-TUBE CULTURES.—In 28 days mat on slant usually appressed, felty, thick, free, white, "cream color" or "pinkish buff" to "cinnamon-buff;" on agar cylinder felty or nodulose to floccose woolly, free, at times with depressed, yellowish areas; carbide odor so pronounced in Petri dishes not noticeable in tubes.

TYPE OF DECAY.—Straw-colored heart rot (*23*). Eleven isolations.

REMARKS.—The most characteristic features of *Polyporus frondosus* in culture are the fine woolly, white or colorless mat, which is at times slightly yellow about the center, the odor of carbide produced in Petri-dish cultures, and the failure of the fungus to grow at a temperature of 31° C. or above.

POLYPORUS GILVUS Schw. ex Fr.

(Pl. 2, *H;* fig. 4, *L.*)

KEY PATTERN.—B–P–I–11 and B–P–M–11.

GROWTH CHARACTERISTICS.—Growth medium or moderately rapid, forming in 14 days a mat 8 to 9 cm. or more in diameter; mat thin, appressed, radiating short cottony, zonate or azonate, adherent, fragile, white or more generally "cream color;" compacted, tough, nodulose, "chamois," "cinnamon-buff" to "buffy brown," abortive or definitely poroid fruiting bodies, scattered over surface of mat or grouped about the center, mycelium about such bodies sometimes tough, felty with pronounced dark areas showing from under side of dish; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–5μ diameter, without clamps, septate, gradually merging into yellowish, much-septate, nonstaining forms in older portions of mat; fibrous hyphae 2μ–4μ diameter, brown, smooth; basidia and basidiospores rare, the

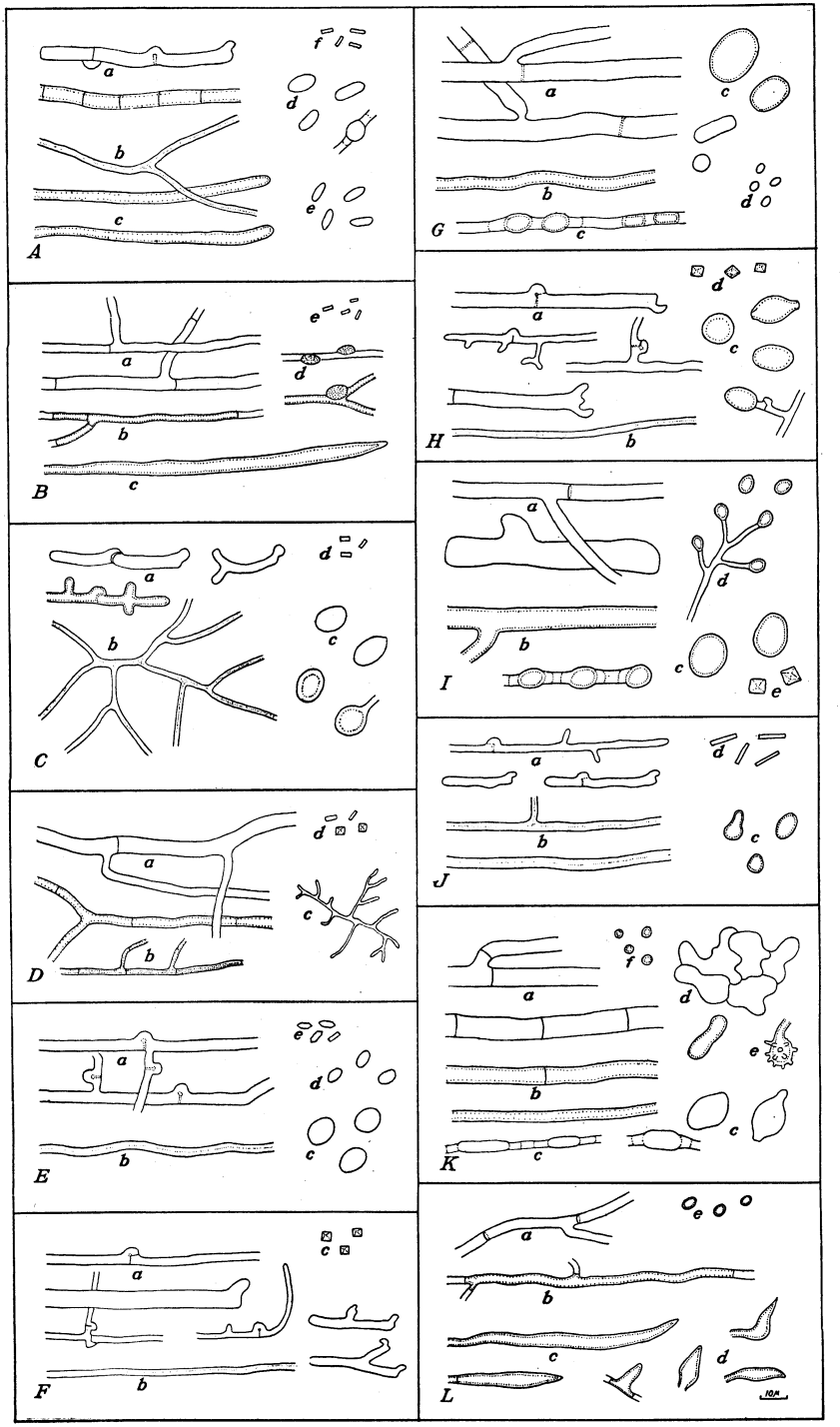

FIGURE 5.—For explanatory legend see opposite page.

latter ellipsoid or subglobose, 3μ–4μ×2μ–3μ; short bulbous-brown setae rare in compacted nodulose areas.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 4.3 cm., 20°; 6.4 cm., 25°; 6.5 cm., 30°; 2.8 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant appressed, cottony, "pinkish buff" to "cinnamon-buff;" usually with prominent raised, very tough, compacted, abortive, "cinnamon-buff" to "clay color" sporophores, either confined to the inoculum or scattered over entire slant surface; on agar cylinder mat usually "cinnamon-buff" to "clay color," compacted, friable, with thin, radiating cottony surface mycelium, and with irregular nodulose areas as dark as "sayal brown;" often showing dark-greenish lines in the agar under the mat and parallel to the margins.

TYPE OF DECAY.—Usually a white sap rot but may occasionally cause limited heart rot (*21*). Two isolations.

REMARKS.—*Polyporus gilvus* may be readily recognized in culture by its short cottony, appressed mat, with dark-brown, compacted, nodulose, abortive fruiting bodies scattered over the surface or grouped about the inoculum, the latter rarely producing basidia or basidiospores.

POLYPORUS GRAVEOLENS Schw. ex Fr.

(Pl. 2, *I;* fig. 5, *A.*)

KEY PATTERN.—B–P–I–1–2–7–11 and E–P–I–1–2–7–11.

GROWTH CHARACTERISTICS.—Growth moderately rapid, forming in 7 days a mat 6 to 8 cm. in diameter; in 14 days mat appressed, velvety or downy, at times floccose, thin, azonate, homogeneous, slightly adherent, either with a restricted white central zone and a "vinaceous buff," "avellaneous," "pinkish cinnamon" or "sayal brown" marginal zone; or some isolations solidly "sayal brown" to "snuff brown;" margin proper even, white, cottony; no definite odor; positive oxidase reaction.

Some isolations form indefinite pores on mat surface in 3 to 4 weeks; basidia and basidiospores usually few to abundant.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–5(–6μ)μ diameter, with clamps, becoming much septate, yellowish in older portions;

FIGURE 5.—*A, Polyporus graveolens: a,* staining hypha; *b,* nonstaining hyphae; *c,* blunt-pointed setal hyphae; *d,* chlamydospores; *e,* basidiospores; *f,* crystals. *B, P. hispidus: a,* staining hyphae; *b,* nonstaining hyphae; *c,* setal hypha; *d,* resinous masses on hyphae; *e,* crystals. *C, P. lucidus: a,* staining hyphae; *b,* nonstaining hyphae; *c,* basidiospores; *d,* crystals. *D, P. ludovicianus: a,* staining hypha; *b,* nonstaining hyphae; *c,* yellow fibrous hyphae from compacted areas; *d,* crystals. *E, P. obtusus: a,* staining hyphae; *b,* nonstaining hypha; *c,* chlamydospores; *d,* basidiospores; *e,* crystals. *F, P. pargamenus: a,* staining hyphae; *b,* nonstaining hypha; *c,* crystals. *G, Poria inflata: a,* staining hyphae; *b,* nonstaining hypha; *c,* chlamydospores; *d,* basidiospores. *H, Polyporus spraguei: a,* staining hyphae; *b,* nonstaining hypha; *c,* chlamydospores; *d,* crystals. *I, P. sulphureus: a,* staining hyphae; *b,* nonstaining hypha; *c,* chlamydospores from submerged hyphae; *d,* chlamydospores from aerial hyphae; *e,* crystals. *J, P, versicolor: a,* staining hyphae; *a,* nonstaining hyphae; *c,* chlamydospores; *d,* crystals. *K, P. zonalis: a,* staining hyphae; *b,* nonstaining hyphae; *c,* chlamydospores; *d,* cuticular cells; *e,* knobbed hyphal end; *f,* basidiospores. *L, Poria andersonii: a,* staining hypha; *b,* nonstaining hypha; *c,* setal hyphae; *d,* bulbous setae; *e,* basidiospores.

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nonstaining hyphae 1μ–5μ diameter, hyaline or yellowish, fibrous, smooth or roughened; blunt-pointed, fibrous, yellow hyphae 3μ–5μ diameter, common, resembling setal hyphae; chlamydospores 5μ–20μ $\times$4μ–8μ, thin-walled, mostly elongate ellipsoid or cylindric; basidiospores few to many, rarely produced before 3 to 4 weeks, cylindric, 7μ–9$\mu\times$3μ–4μ.

TEMPERATURE RELATIONS.—Optimum approximately 25° C. Average mat diameters in 7 days in dark at constant temperatures follow: 5.0 cm., 20°; 8.0 cm., 25°; 6.0 cm., 31°; trace, 35°.

TEST-TUBE CULTURES.—In 28 days mat on upper part of slant thin, tough, appressed, without aerial hyphae, somewhat pulverulent, "sayal brown;" on lower part of slant raised, tough, compacted, felty, "light pinkish cinnamon" to "cinnamon" or "sayal brown," occasionally forming well-developed "light pinkish cinnamon" pores; on agar cylinder, white or "pinkish buff" with small, irregular "ochraceous-tawny" or "cinnamon-brown" spots.

TYPE OF DECAY.—White sap and heart rot (*15, p. 118*). Three isolations.

REMARKS.—*Polyporus graveolens* is readily recognized in culture by its appressed, white to "vinaceous-buff," "pinkish cinnamon" to "sayal brown" mat, its low optimum of 25° C. and failure to grow at 35° C., and by its blunt-pointed, yellow setae.

POLYPORUS HISPIDUS Bull. ex Fr.

(Pl. 2, *J;* fig. 5, *B.*)

KEY PATTERN.—C–P–M–7–11.

GROWTH CHARACTERISTICS.—Growth medium, forming in 14 days a mat 6 to 8 cm. in diameter, loose cottony or woolly, raised, forming a definite mound on the agar surface, free or slightly adherent, azonate, rarely somewhat compacted, felty, even-colored, "cream color" to "straw yellow" and "naples yellow" or "mustard yellow;" margin white, cottony, even or appressed, colorless, narrow to wide; at times mat irregular in outline; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–5μ diameter, septated but without clamps; nonstaining hyphae 2μ–3(–5μ)μ diameter, fibrous with thick yellow or brownish walls; setal hyphae 4μ–7μ diameter, common, walls thick, brownish or yellowish; brown or yellow resinous exudations common on both staining and nonstaining hyphae.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 2.3 cm., 20°; 3.8 cm., 25°; 4.3 cm., 30°; 1.8 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant raised, fine woolly to compacted woolly, forming a tough, thick pad, free, "chamois," "warm buff," "ochraceous-buff" to as dark as "buckthorn brown" on upper surface of the pad, rest of pad lighter, "cream color" to "warm buff;" on agar cylinder felty, tough, free, often with alternating bands of color, "cream-buff," "warm buff" to "chamois" and "buckthorn brown."

TYPE OF DECAY.—White heart rot usually associated with trunk cankers (*36*). Six isolations.

REMARKS.—*Polyporus hispidus* resembles *Poria andersonii* in mat color, growth rate, and setal hyphae. However, it should not be con-

fused with the latter species, as the mat is much lighter in color and never produces the short, bulbous setae so common in cultures of *P. andersonii*. *Polyporus dryophilus* superficially resembles *P. hispidus* but does not produce setal hyphae.

POLYPORUS LUCIDUS Leyss. ex Fr.

(Pl. 2, *K*; fig. 5, *C*.)

KEY PATTERN.—A–P–I–1–2–11 and B–P–I–1–2–11.

GROWTH CHARACTERISTICS.—Growth moderately rapid, forming in 7 days a mat 6 to 9 cm. in diameter; central zone appressed, indefinite, pulverulent, white, forming a thin film with little or no aerial hyphae; marginal zone short cottony; margin proper white, cottony, even.

In 14 days entire mat appressed, compacted, tough, thin felty, adherent, pulverulent without aerial mycelium or with only a thin downy covering, white or more generally "massicot yellow," "cream color" or at times "light drab" color either evenly distributed or in concentric rings about the inoculum, mat surface turning yellowish brown wherever scraped or rubbed; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae in 14 days usually broken up into short irregular lengths 2μ–5 (–6μ)μ diameter, clamps numerous, in old cultures with many short empty sections; nonstaining hyphae forming much-branched complexes, 1μ–3 (–4μ)μ diameter, smooth, without clamps, hyaline or yellow; chlamydospores 6μ–25μ $\times$ 6μ–12μ, ovoid to ellipsoid, usually very numerous, either with thin or thick hyaline walls, thin-walled forms resembling vesicular cells when empty.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 5 days in dark at constant temperatures follow: 3.8 cm., 20°; 5.4 cm., 25°; 7.1 cm., 30°; 5.7 cm., 35°; 1.0 cm., 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant tough, appressed, thin or thick felty, pulverulent, white or more generally "colonial buff," "olive-ocher" to "honey yellow" or "isabella color," often with numerous pits caused by brown or yellowish exudation droplets, at times with glass opposite slant covered by feathery or pulverulent hyphae; on agar cylinder white, tough, felty, free.

TYPE OF DECAY.—White heart rot (*18*, *31*). Twenty-two isolations.

REMARKS.—*Polyporus lucidus* is so closely related to *P. curtisii* as to make any separation between the two species in culture impractical. Three sporophore isolates of *P. curtisii* were compared with those of *P. lucidus*, and although minor differences were noted a study based on more isolates of the former species will be needed before any definite statement can be made as to the distinctness of the two species in culture. For practical purposes the two fungi have been considered as belonging to a single complex and all isolations involving this complex were classified as *P. lucidus*.

Polyporus lucidus can be readily identified in culture by its appressed white or yellowish pulverulent mat, which usually lacks aerial hyphae in 14-day-old cultures and turns yellowish brown when the surface is scraped or rubbed.

POLYPORUS LUDOVICIANUS (Pat.) Sacc. and Trott.

(Pl. 2, *L*; fig. 5, *D*.)

KEY PATTERN.—B–P–S–11.

GROWTH CHARACTERISTICS.—Growth slow, forming a mat 3 to 4.5 cm. in 14 days; mat at first thin, velvety, white, with an indeterminate margin, or mat somewhat compacted, felty, white or "straw yellow;" in 14 days surface appressed, compacted, friable, nodulose velvety or downy, generally with irregular margins, color unevenly distributed, faintly white to "light ochraceous-buff" or "cream color" to "chamois," "olive-ocher," and "yellow ocher;" all cultures showing dark-brown, opaque mats when viewed from under side and usually with a light-brown halo in the agar surrounding the mat; margin proper appressed, colorless, narrow to wide, fairly even; no distinctive odor; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–6μ diameter, those from growing margins thin-walled, without clamps, sparsely septate; those from staled portions yellowish, nonstaining, many septate, fibrous yellow hyphae 0.5μ–1μ diameter, much branched, little septate, common in compacted areas, hyphae in compacted areas often obscured by yellowish, agglutinating material.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 1.5 cm., 20°; 2.6 cm., 25°; 3.2 cm., 30°; 0.7 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant compacted, felty, friable, with very little growth on upper part, "antimony yellow," "buckthorn brown," or "ochraceous tawny;" on agar cylinder compacted, felty, thick, friable zones, "cinnamon" or more generally "buckthorn brown" to "cinnamon brown;" margin usually abrupt, distinct from rest of mat, white or "warm buff" to "cinnamon;" agar under mat usually much darkened, often greenish about the margins.

TYPE OF DECAY.—White pocket rot (*31*). Six isolations.

REMARKS.—*Polyporus ludovicianus* is characterized by its slow growth rate and the dark-brown, opaque appearance of the under side of the mat, which is particularly noticeable in test-tube cultures. The very small fibrous hyphae common in the compacted portions of the mat are also distinctive.

POLYPORUS OBTUSUS Berk.

(Pl. 2, *M*; fig. 5, *E*.)

KEY PATTERN.—A–P–I–1–2–11 and A–P–M–1–2–11.

GROWTH CHARACTERISTICS.—Growth moderately rapid to medium, forming in 7 days a mat 3 to 5 cm. in diameter, either raised, white, cottony with a loose cottony margin; or with a restricted or extensive raised, white, cottony central zone and an irregular, appressed, thin, colorless or faintly white marginal zone.

In 14 days mat 7 to 9 cm. or more in diameter, very variable in appearance, surface entirely raised, loose cottony or appressed fine woolly, adherent, white; at times the same mat will be irregularly loose cottony to fine woolly; odor faint, not readily describable; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–5(–6μ)μ diameter, clamps abundant, with large prominent "eyes;" nonstaining hyphae 2μ–4μ diameter, thick-walled, fibrous, smooth, hyaline, without clamps; chlamydospores common, globose to ellipsoid, 6μ–15μ × 6μ–15μ, thin-walled, often empty; oidia common in some cultures, rare in others; basidiospores rarely formed in culture, subglobose to ellipsoid, 5μ × 8μ, 1-guttulate.

TEMPERATURE RELATIONS.—Optimum approximately 31° C. Average mat diameters in 7 days in dark at constant temperatures follow: 2.9 cm., 20°; 5.5 cm., 25°; 7.8 cm., 31°; 6.6 cm., 35°; 0, 41°.

TEST-TUBE CULTURES.—In 28 days mat on slant loose cottony, raised, forming a decided pad, white, often completely filling tube between agar slant and cotton plug; on agar cylinder white, cottony, homogeneous, fragile.

TYPE OF DECAY.—White heart rot (*37*). Twelve isolations.

REMARKS.—Cultures of *Polyporus obtusus* resemble those of *Irpex mollis* so closely that no method has yet been devised to tell them apart. *I. mollis* is rather common on much-decayed, down logs of oaks but is also found on living trees of several hardwood species, often associated with trunk cankers. In the oak decay study *P. obtusus* sporophores were frequently found associated with heart rot in living trees and all isolations of the *P. obtusus* type were referred to that species. In view of the similarity that exists between cultures of *P. obtusus* and *I. mollis*, further studies would be desirable to determine if this similarity is accidental or due to close relationship between the two species.

POLYPORUS PARGAMENUS Fr.

(Fig. 5, *F.*)

KEY PATTERN.—A–P–I–1–11 and F–P–I–1–11.

GROWTH CHARACTERISTICS.—Growth usually moderately rapid, forming a mat over 9 cm. in diameter in 14 days, appressed felty or nodulose felty, azonate, homogeneous, free or slightly adherent, rather fragile, white, usually with a pale "pinkish vinaceous" tinge either locally or over entire surface; margin proper appressed, colorless, slightly fimbriate; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–7μ diameter, with many clamps, broken up into short lengths in 14-day-old cultures; nonstaining hyphae, fibrous, thick-walled, 1μ–4μ diameter, without clamps.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 4.4 cm., 20°; 6.5 cm., 25°; 7.0 cm., 30°; 2.8 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 14 days mat on slant fine woolly on upper part to loose woolly or cottony on lower part, becoming in 28 days compacted felty or nodulose felty, white, usually with a "pale vinaceous-lilac" tinge; lacerate vinaceous or white pores occasionally develop in 6 to 8 weeks; on agar cylinder white, cottony or felty, thick, free.

TYPE OF DECAY.—Usually a white sap rot but sometimes limited heart rot in connection with wounds.

REMARKS.—Rather easily recognized in tube cultures by the "pale vinaceous-lilac" color, which develops on the upper part of the slant. This color, however, fades in cultures 8 weeks of age or older.

POLYPORUS SPRAGUEI Berk. and Curt.

(Pl. 2, *O*; fig. 5, *H*.)

KEY PATTERN.—A–O–I–1–2–11 and A–O–M–1–2–11.

GROWTH CHARACTERISTICS.—Growth moderately rapid, rarely medium, forming a mat 8 to 9 cm. or more in diameter in 14 days, irregularly nodulose or floccose velvety to felty, compacted, free, zonate or azonate, at times with a raised woolly mound over inoculum, white; margin thin, short cottony, fragile, even; odor usually pronounced, sweet acid; negative oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae either 2μ–5μ diameter, much branched, with simple clamps, or 5μ–7μ little branched, thin-walled, fragile, with single or double clamps; nonstaining hyphae 2μ–5μ diameter, hyaline, smooth, fibrous, without clamps or 5μ–7μ usually with broken clamps at end of short sections; chlamydospores numerous, ovoid to ellipsoid, 8μ–20μ × 6μ–15μ, with a thick hyaline wall.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 3.8 cm., 20°; 5.8 cm., 25°; 6.9 cm., 30°; 1.0 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant tough, compacted felty, adherent, nodulose, with definite poroid areas forming on upper part of slant, white; on agar cylinder white, felty, adherent.

In 6 to 8 weeks mat on slant white or slightly "cinnamon-buff," very tough, with finely pitted or clearly poroid areas on upper part of slant, often on mounds that develop against the glass and somewhat detached from rest of mat and composed of thick-walled hyaline hyphae; usually lacking aerial mycelium, felty with crystalline material deposited where mycelium on slant comes in contact with glass.

TYPE OF DECAY.—Brown rot (*41*). Twenty-seven isolations.

REMARKS.—*Polyporus spraguei* is difficult to separate from *Daedalea quercina* in culture. However, the former has not been observed to form basidia and basidiospores in culture as *D. quercina* often does. The two species are best separated in 6- to 8-week-old test-tube cultures, as here *P. spraguei* forms a tough, compacted mat on the slant which lacks aerial mycelium and usually has pitted or poroid areas, whereas *D. quercina* produces a fine woolly, loose fragile mat on the slant without any indication of pores.

POLYPORUS SULPHUREUS Bull. ex Fr.

(Pl. 3, *A*; fig. 5, *I*.)

KEY PATTERN.—E–O–I–2–10 and E–O–M–2–10.

GROWTH CHARACTERISTICS.—Growth moderately rapid or medium, forming in 14 days a mat 8 to 9 cm. or over in diameter, usually moderately appressed, fragile, azonate or obscurely zoned, at times with a thin, definite, central zone but more generally homogeneous, moist granular to moist woolly, composed largely of chlamydospores, "pinkish buff," "light vinaceous-cinnamon" to "ochraceous-salmon;" margin proper colorless, appressed even; odorless; negative oxidase reaction.

HYPHAL CHARACTERISTICS.—Both submerged and superficial hyphae staining in erythrosin, 4μ–10μ diameter, occasionally with short sections up to 15μ, very thin-walled, without clamps but with numer-

ous septa, in old cultures with a slightly yellowish content; fibrous hyphae very rare usually not formed until cultures have aged, thick-walled, hyaline, 4μ–10μ diameter; chlamydospores very numerous, entire mat becoming in time a powdery mass of spores, those produced by much-branched aerial hyphae uniform, thick-walled when mature, ovoid or ellipsoid, 5μ–10μ, those produced by submerged hyphae irregular-shaped, single or in chains, 9μ–30μ × 8μ–20μ.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 4.3 cm., 20°; 5.8 cm., 25°; 5.6 cm., 30°; trace, 35°.

TEST-TUBE CULTURES.—In 28 days entire mat powdery or granular, loose, at times slightly woolly, composed of a mass of chlamydospores, "light vinaceous-cinnamon," "light pinkish cinnamon" to "ochraceous-salmon."

TYPE OF DECAY.—Brown checked rot (*10*, *40*). Forty-two isolations.

REMARKS.—The fungus can be readily recognized in culture by its "light vinaceous-cinnamon" to "ochraceous-salmon" mat, which becomes a mass of chlamydospores, and by its large, clampless hyphae.

POLYPORUS VERSICOLOR L. ex Fr.

(Pl. 3, *B*; fig. 5, *J*.)

KEY PATTERN.—A–P–F–1–11.

GROWTH CHARACTERISTICS.—Growth rapid, forming a mat over 9 cm. in diameter in 7 days, short floccose cottony to fine woolly, azonate, rather fragile, moderately appressed, white, with the central zone characteristically thinner, more appressed, faintly white, which causes it to appear darker than the surrounding mycelium.

In 14 days mat very tough, white, compacted felty or nodulose felty, free, azonate, often with a somewhat raised, nodulose, much-compacted area about the center, often water-soaked in appearance and usually with large or small exudation drops of clear liquid on the surface; odor fungoid; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–5(–7μ)μ diameter, with abundant clamps, in 14 days much disorganized and broken up into short lengths; nonstaining hyphae 1μ–4(–5μ)μ diameter, smooth, hyaline, fibrous, little-branched and without clamps; chlamydospores very rare.

TEMPERATURE RELATIONS.—Optimum temperature approximately 30° C. Average mat diameters in 4 days in dark at constant temperatures follow: 4.7 cm., 20°; 6.3 cm., 25°; 8.2 cm., 30°; 6.0 cm., 35°; 0.9 cm., 41°.

TEST-TUBE CULTURES.—In 28 days mat on slant appressed, tough, thick or thin felty, without aerial mycelium, free, white; on agar cylinder not so closely compacted, felty, white for most part, often with yellow bands of crystalline material.

TYPE OF DECAY.—White sap rot of oaks but will occasionally attack heartwood to a limited extent in back of wounds.

REMARKS.—*Polyporus* (*Polystictus*) *versicolor* has been studied in culture by several workers, notably Bayliss (*2*), who investigated its biology in detail, and Fritz (*14*), who described mats produced on several different agars and also microscopic structure.

The fungus belongs in the white, fast-growing group with *Polyporus fissilis* and *Fomes geotropus* but can be separated from them by microscopic characters.

POLYPORUS ZONALIS Berk.

(Pl. 3, *C*; fig. 5, *K*.)

KEY PATTERN.—A–P–I–2–4–8–9–11.

GROWTH CHARACTERISTICS.—Growth moderately rapid, forming in 7 days a mat 7 to 9 cm. in diameter; in 14 days mat appressed, with radiating cottony strands, adherent, fragile, white, usually with appressed, white or slightly yellowish crusty or compacted, slightly raised, nodulose areas about the center or scattered irregularly over the surface; the mycelium against the margins of the dish usually loose, cottony, raised; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–$8(-10\mu)\mu$ diameter, very thin-walled, without clamps, much-septate; nonstaining hyphae same or thick-walled, fibrous, septate, 4μ–6μ diameter; chlamydospores irregular in shape, globose to elongate ellipsoid, 10μ–$20\mu \times 6\mu$–12μ, thin-walled; oidia rare or common, at times difficult to distinguish from immature chlamydospores; inflated cells characteristic, at first thin-walled, irregular, forming a definite mosaic pattern in crusty areas, continuous, later becoming thick-walled; hyphal ends covered with short knobs or definite spines usually associated with crusty areas, either abundant or rare; basidiospores formed in tube cultures, globose, 4μ–5μ.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 5 days in dark at constant temperatures follow: 3.8 cm., 20°; 6.5 cm., 25°; 8.0 cm., 30°; 3.0 cm., 35°; 0, 41°.

TEST-TUBE CULTURES.—In 28 days mat on slant appressed, crusty, white or yellowish, fragile, often with a well-developed sporophore on upper part of slant, pores orientated toward mouth of test tube and with a definite ridge on side toward the slant; tube mouths "light pinkish cinnamon;" basidiospores usually produced in abundance, somewhat cream-colored in mass; on agar cylinder mat irregularly crusty, thick, friable, white or mottled yellowish, often with prominent hyphal strands in the agar under the mat.

TYPE OF DECAY.—White pocket rot, illustrated by Overholts (*31*). Ten isolations.

REMARKS.—A comparison was made between isolates of *Polyporus zonalis* and two isolates of *Poria undata* (Pers.) Bres. The latter were the same as *Polyporus zonalis* as far as appearance of the mats, microscopic structures, and temperature relations were concerned.

Polyporus zonalis may be readily recognized by its white, cottony mat, prominent radiating strands, and the presence of characteristic irregular inflated cells which form a continuous pattern, usually most abundant in the crusty areas on the mat surface. The knobbed or toothed hyphal ends are also distinctive.

PORIA ANDERSONII (Ell. and Ev.) Neuman

(Pl. 3, *D;* fig. 5, *L.*)

KEY PATTERN.—C-P-M-7-11.

GROWTH CHARACTERISTICS.—The following description is adapted from Campbell and Davidson (*7*):

Growth medium, forming in 14 days a mat 4.5 to 7 cm. in diameter; mat very variable, usually raised, but at times appressed, zonate, often definitely segmented, mostly felty and occasionally long cottony about the inoculum, "light orange-yellow" to "yellow ocher," "raw sienna" and "buckthorn brown;" margin either abrupt, cottony or thin, appressed, colorless or yellowish, segmented cultures showing both extremes; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Hyphae staining with eosin, 2μ–5μ diameter, no clamps; from staled areas under center, yellowish, collapsed, nonstaining, with numerous septa and often broken up into irregular lengths; fibrous hyphae dark brown, 2μ–4(–5μ)μ diameter; setal hyphae common or rare, up to 8μ diameter and 250μ long; bulbous setae common in compacted, staled areas and in fruiting structures; basidiospores occasionally formed in poroid areas, ellipsoid, smooth, yellowish green, 6μ–8μ×3.5μ.

TEMPERATURE RELATIONS.—Optimum temperature between 30° and 35° C. Average mat diameters in 7 days in dark at constant temperatures follow: 1.0 cm., 20°; 3.1 cm., 25°; 5.2 cm., 30°; 5.5 cm., 35°; slight growth at 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant compacted, woolly to felty, "yellow ocher" to "buckthorn brown" and "raw sienna"; on agar cylinder "mustard yellow" to "antimony yellow" and "yellow ocher," often with pronounced zones, tough, felty, free; occasionally developing well-formed pores on a raised mycelial pad at the lower end of slant.

TYPE OF DECAY.—White, soft, spongy rot of sapwood and heartwood. Sixty-six isolations.

REMARKS.—The fungus fruits readily on oak block cultures in wide-mouth flasks, the sporophore usually forming between the agar and the glass. The sporophores are much distorted by pressure but produce yellowish-green basidiospores in abundance.

This fungus falls into the same group as *Polyporus hispidus* but is usually darker colored, forms a more compacted mat, and shows greater variation in the size and shape of setal hyphae. *P. hispidus* never forms bulbous hyphae so characteristic of *Poria andersonii*.

PORIA COCOS (Schw.) Wolf

(Pl. 3, *E;* fig. 6, *A.*)

KEY PATTERN.—E-O-F-8-10 and D-O-F-8-10.

GROWTH CHARACTERISTICS.—Growth variable, usually rapid, forming a mat 9 cm. in diameter in 6 days; in 14 days mat either "cartridge buff" or "pale pinkish buff," appressed cottony at center to loose cottony at margins, fragile, and with superficial hyphae showing numerous fine guttation drops; or appressed, solidly or irregularly, "army brown" to "vandyke brown," often with margins loose cottony; when first isolated inclined to be appressed, brown, but

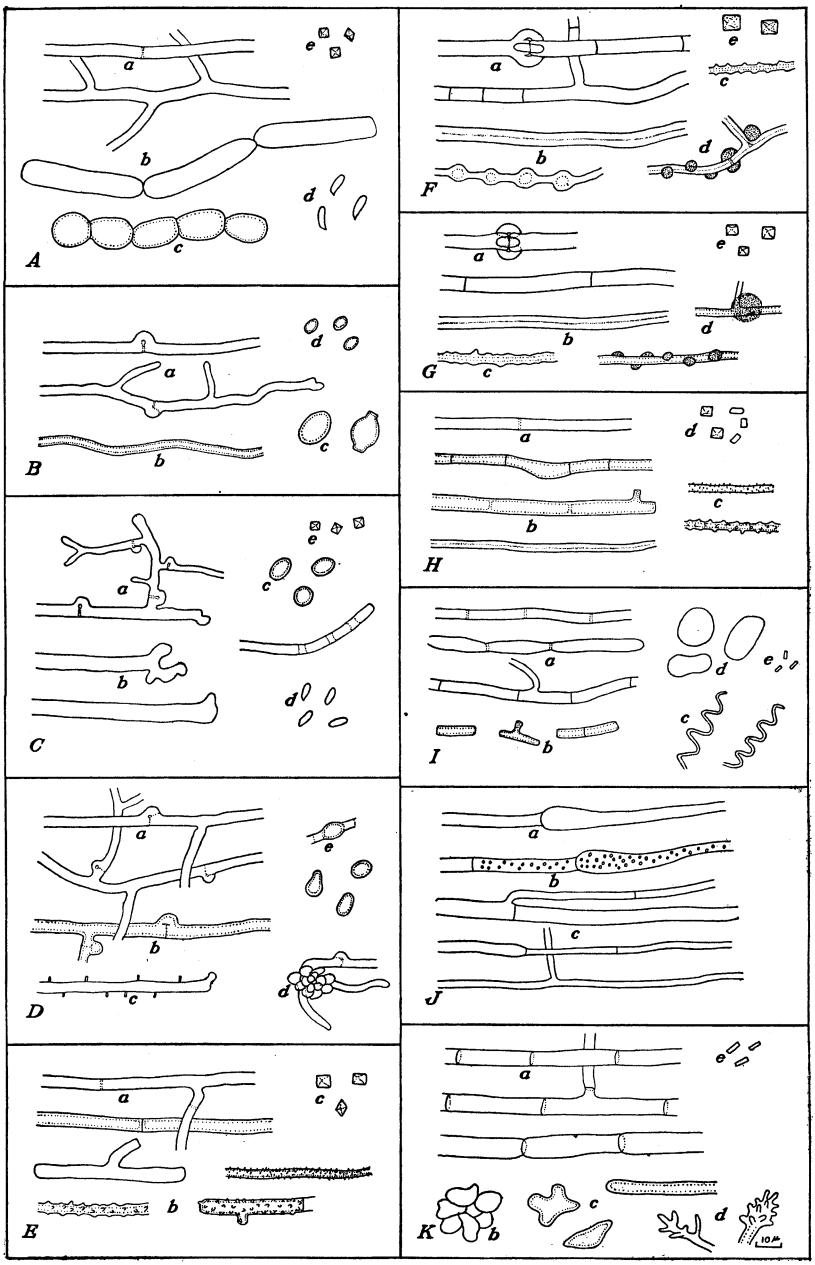

FIGURE 6.—For explanatory legend see opposite page.

becoming loose cottony, "pale pinkish buff" on repeated transfer; large coarse lacerate white pores occasionally formed flat on mat surface in cultures 14 days old; negative oxidase reaction, appressed dark isolations often giving inconsistent results with slightly positive reactions, especially with gallic acid.

HYPHAL CHARACTERISTICS.—Submerged and superficial hyphae 2μ–15μ diameter, thin-walled, septations prominent, often constricted, without clamps, breaking up into short irregular lengths with interspersed empty cells, those in vigorous condition staining deeply with erythrosin or brown nonstaining in colored areas; irregular inflated cells either single or in chains, usually common; basidiospores 7μ–9μ × 3μ–4μ, cylindric.

TEMPERATURE RELATIONS.—Constant temperature studies unsatisfactory owing to the great variation between growth rates of light- and dark-colored isolates. Optimum approximately 30° C.

TEST-TUBE CULTURES.—In 28 days either "pale pinkish buff," loose cottony, fragile, raised over slant, or appressed "vinaceous-buff" to as dark as "vandyke brown;" surface mycelium showing fine guttation drops; coarsely poroid to lacerate, white or buff-colored fruiting structures often formed, producing basidiospores in abundance.

TYPE OF DECAY.—Brown rot of roots and heartwood of trunk. Forty-five isolations.

REMARKS.—Identification of a number of isolates from oak and other hosts of *Poria cocos* was made by comparison of these isolates with No. 59183 from a sclerotium of *P. cocos* collected by J. A. Stevenson of the Division of Mycology and Disease Survey, near Annapolis, Md., June 1935. This isolate, as well as a number of other similar isolates, fruits readily in Petri-dish cultures or test tubes, producing basidiospores in abundance.

Wolf (*43*) described the fungus in culture from a sclerotium and succeeded in demonstrating apparently normal fruiting and typical basidiospores.

The most noticeable features of *P. cocos* in culture are its fragile "pale pinkish buff" mat; the exceptionally large, septate, often much-constricted hyphae; and the large, connected, inflated cells. When fruiting occurs the cylindric basidiospores produced in coarse poroid or lacerate sporophores are also distinctive.

FIGURE 6.—*A, Poria cocos: a,* staining hyphae; *b,* large thin-walled, hyphae; *c,* inflated cells; *d,* basidiospores; *e,* crystals. *B, P. nigra: a,* staining hyphae; *b,* nonstaining hypha; *c,* chlamydospores; *d,* basidiospores. *C, Poria* sp.: *a,* staining hypha; *b,* nonstaining hyphae; *c,* chlamydospores; *d,* basidiospores; *e,* crystals. *D, Schizophyllum commune: a,* staining hypha; *b,* nonstaining hypha; *c,* hypha with short side branches or crystals; *d,* hyphal knot; *e,* chlamydospores. *E, Stereum frustulosum: a,* staining hyphae; *b,* nonstaining, rough hyphae; *c,* crystals. *F, S. gausapatum: a,* staining hyphae; *b,* nonstaining hyphae; *c,* rough-walled hyphae; *d,* hypha with resinous masses; *e,* crystals. *G, S. rameale: a,* staining hyphae; *b,* nonstaining hypha; *c,* rough-walled hypha; *d,* hyphae with resinous masses; *e,* crystals. *H, S. subpileatum: a,* staining hyphae; *b,* nonstaining hyphae; *c,* rough-walled hyphae; *d,* crystals. *I, Ustulina vulgaris: a,* staining hyphae; *b,* black nonstaining hyphae; *c,* spiral hyphae; *d,* cuticular cells; *e,* crystals. *J,* Unidentified agaric: *a* and *c,* staining hyphae; *b,* hypha with abundant oil droplets. *K,* Unidentified fungus: *a,* staining hyphae; *b,* cuticular cells; *c,* thick-walled cuticular cells; *d,* knobbed hyphal ends; *e,* crystals.

PORIA INFLATA Overh.

(Pl. 2, *N*; fig. 5, *G*.)

KEY PATTERN.—A–O–M–2–10 and A–O–M–2–3–10.

GROWTH CHARACTERISTICS.—Growth variable, mostly medium, forming a mat 7 to 9 cm. or more in diameter in 14 days; mat fine woolly to floccose-woolly, occasionally downy, appressed, very fragile, thin, azonate, homogeneous, somewhat adherent, often with fine guttation drops on the surface hyphae, colorless, faintly white to slightly pinkish; margin colorless or faintly white, even; odor indefinite, sweetish; negative oxidase reaction.

HYPHAL CHARACTERISTICS.—Submerged hyphae staining, 4μ–15μ diameter, very thin-walled, no clamps, much-septated and often broken into short cells with empty, collapsed cells common; superficial hyphae about same, thin-walled, staining deeply with erythrosin; fibrous hyaline hyphae, 3μ–5μ diameter, occasionally formed in old test-tube cultures; chlamydospores 5μ–30μ×5μ–30μ, usually very abundant, ovoid, ellipsoid to short cylindric, often produced in chains, when mature with a thin hyaline wall; oidia occasional; basidiospores, from sporophore produced in flask culture, ellipsoid, 4μ–5μ× 3μ–3.5μ.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 3.6 cm., 20°; 5.2 cm., 25°; 6.3 cm., 31°; 2.6 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant pulverulent to moist granular, thin, fragile or rarely somewhat compacted about inoculum or at top of slant, faintly white to white and at times "cartridge buff" or "tilleul buff;" on agar cylinder pulverulent to granular, fragile, moist, homogeneous, white to "cartridge buff."

TYPE OF DECAY.—Brown heart rot. Nine isolations.

REMARKS.—Isolates of this fungus resemble pale or colorless *Polyporus sulphureus*. Microscopically, however, the latter is distinct in possessing small chlamydospores borne on much-branched aerial hyphae.

Poria inflata was collected on a rotting red-oak log at Lewisburg, W. Va. Identification was made by L. O. Overholts, who recently described the species (*32*). Isolations made from this sporophore and associated rot agreed culturally with those previously obtained from oak decay.

PORIA NIGRA Berk.

(Pl. 3, *F*; fig. 6, *B*.)

KEY PATTERN.—A–O–M–1–2–11 and B–O–M–1–2–11.

GROWTH CHARACTERISTICS.—Growth medium, forming in 7 days a mat 4 to 5 cm. in diameter; somewhat raised, fine woolly at center to short cottony at margin; margin faintly white, slightly fimbriate.

In 14 days mat 8 to 9 cm. in diameter; raised, felted, cottony to woolly, free, entirely white or more commonly yellowish or "cinnamon-brown" about center or in a wide concentric ring, such areas more compacted than white portions; negative oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–5μ diameter, clamps common; nonstaining hyphae 2μ–4μ diameter, hyaline or with brownish walls, fibrous, smooth; chlamydospores 9μ–18μ×8μ–12μ, ovoid to elongate ellipsoid or barrel-shaped, with moderately thick,

hyaline walls; basidiospores rare, produced in test-tube cultures, 6μ–7μ×4μ–5μ, smooth, ellipsoid, dark smoky brown.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 2.3 cm., 20°; 4.5 cm., 25°; 6.0 cm., 30°; 2.7 cm., 35°; 0,40°.

TEST-TUBE CULTURES.—In 28 days mat on slant thick, felted, free, forming a definite pad, "light cinnamon-drab" on upper part of slant, wood color on loose mycelium against the tube; on agar cylinder usually white, felty.

In 6 to 8 weeks an occasional isolate develops definite, "natal brown" or lighter pores on upper part of slant with mature basidiospores rare.

TYPE OF DECAY.—Brown heart rot associated with fire wounds and other trunk injuries. Twelve isolations.

REMARKS.—*Poria nigra* sporophores in nature are usually devoid of spores. Citations as to spore sizes are usually taken from Murrill (*29, p. 15*). The color and size of spores produced in culture agree with his observations.

The fungus may be recognized in culture by its even white mat which gradually becomes "cinnamon-brown" to "light cinnamon-drab" on aging. Usually characteristic dark-brown sporophores form on wood-block cultures after from 6 to 8 months.

PORIA sp.

(Pl. 3, *G*; fig. 6, *C*.)

KEY PATTERN.—A–O–M–1–2–11–16 and A–O–M–1–2–5–6–11–16.

GROWTH CHARACTERISTICS.—Growth medium, forming a mat 6 to 8 cm. in diameter in 14 days; mat radiating short cottony or floccose cottony, usually, definitely zonate, and occasionally producing prominent sectors; fragile, thin, white or rarely with a slightly yellowish area about the center; nodulose, waxy patches develop on the surface mycelium, at times abundant before 14 days, but usually requiring a longer time to form, often producing basidia and basidiospores; margin proper white, cottony, even; odor that of rotten cabbage in old cultures; negative oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae of two kinds, one 1μ–5μ diameter, with many simple clamps, much-branched, the other 4μ–7μ diameter, smooth, little-branched, with simple and multiple clamps, becoming thick-walled, hyaline on aging, often with clublike ends where clamps have broken; chlamydospores mostly 5μ–12μ×4μ–9μ, ellipsoid, with thick hyaline walls, very abundant, in old cultures surface mycelium practically all transformed into chlamydospores; oidia rare; basidia formed in nodulose patches on surface lacking or fairly common in 14 days; basidiospores oblong 6μ–7μ×3μ–3.5μ.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 2.4 cm., 20°; 3.9 cm., 25°; 5.4 cm., 30°; 4.8 cm., 35°; 0, 41°.

TEST-TUBE CULTURES.—In 28 days mat on slant usually appressed, fragile, pulverulent to floccose or somewhat nodulose, white, often with definite raised patches on upper part of slant which develop into shallow pores in 6 to 8 weeks; glass opposite slant coated with a feathery or cottony mycelium; on agar cylinder mat fragile, white, cottony,

yellowish about the margins from patches of crystalline material; odor of rotten cabbage.

TYPE OF DECAY.—Brown heart rot. Thirteen isolations.

REMARKS.—The fungus fruits readily on oak blocks in flask cultures, forming well-developed sporophores against the glass in the upper part of the flask. The pores at times form in what appear to be small crowded pilei, but the general appearance resembles a *Poria*. On drying, the sporophores produced in culture become very fragile, brittle, and chalky. At the present time it is not possible to identify this fungus.

SCHIZOPHYLLUM COMMUNE Fr.

(Pl. 3, *H;* fig. 6, *D.*)

KEY PATTERN.—A–O–I–1–2–11–16 and A–P–I–1–2–11–16.

GROWTH CHARACTERISTICS.—Growth moderately rapid, forming in 7 days a mat 5 to 7 cm. in diameter; in 14 days mat white, loose cottony, zonate or azonate, homogeneous; or appressed, radiating short cottony or felty, inclining to stale at the margins; either type forming well-developed sporophores or with nodulose areas at center and margin from which sporophore later develops: mat adherent, forming a tough, thick, gelatinous layer on agar surface; odor very disagreeable, in constant temperature chamber at 30° C. distinctly that of garlic; negative oxidase reaction on gallic acid medium, positive on tannic acid in from 7 to 14 days.

HYPHAL CHARACTERISTICS.—Staining hyphae 2μ–6(–8μ)μ diameter, thin-walled, with many clamps, nonstaining hyphae 3μ–7μ diameter with clamps, thick-walled, hyaline, often with swollen places; at times hyaline hyphae show numerous, short, granular side branches at right angles to the hyphae, which Vanin (*38*) considered to be granular crystals; hyphal knots common in 7-day-old cultures becoming obscured in older ones; chlamydospores rare, 4μ–7μ diameter.

TEMPERATURE RELATIONS.—Optimum temperature between 30° and 35° C. Average mat diameters in 6 days in dark at constant temperatures follow: 4.9 cm., 20°; 6.9 cm., 25°; 8.6 cm., 30°; 8.2 cm., 35°; 3.4 cm., 41°.

TEST-TUBE CULTURES.—In 28 days mat white, appressed cottony, tough, forming a thick gelatinous film on the agar, usually with well-developed sporophores on agar cylinder and slant.

TYPE OF DECAY.—White sap rot.

REMARKS.—*Schizophyllum commune* has many distinctive features in culture, namely: A disagreeable, prominent odor; the tough gelatinous layer formed in the agar under the mat; the ability to grow well at 41° C.; the unusual reaction with gallic and tannic acid, being negative on the former and positive on the latter; and the ease with which it fruits in culture.

STEREUM FRUSTULOSUM Pers. ex Fr.

(Pl. 3, *I;* fig. 6, *E.*)

KEY PATTERN.—B–O–M–11–16 and E–O–M–11–16.

GROWTH CHARACTERISTICS.—Growth medium, forming in 14 days a mat 6 to 8 cm. in diameter; central zone usually restricted, indefinite, "orange-buff" to "capucine orange," loose cottony to woolly; marginal

zone wide, white or "pale orange-yellow," cottony; margin proper white, raised, cottony, fairly even; odorless; negative oxidase reaction. This is contrary to expectations as the fungus produces a white pocket rot.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–7μ diameter, thin-walled, without clamps, septate; nonstaining hyphae fibrous, hyaline or yellow 1μ–5(–6μ)μ diameter, smooth- or rough-walled; intermediate forms common, especially hyphae with thick hyaline walls and a thin thread of staining content.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 4.4 cm., 20°; 5.8 cm., 25°; 5.3 cm., 30°; 1.8 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant appressed, cottony or felty, "pale yellow-orange" to "capucine orange;" on agar cylinder radiating fibrous cottony, white to "pale yellow-orange."

TYPE OF DECAY.—White pocket rot (*10*). One hundred and thirty-five isolations.

REMARKS.—*Stereum frustulosum* resembles *S. subpileatum* in culture but may be distinguised by its lighter, orange mat, its lack of odor, and by its consistent negative oxidase reaction.

STEREUM GAUSAPATUM Fr.

(Pl. 3, *J*; fig. 6, *F*.)

KEY PATTERN.—B–P–I–1–11–16.

GROWTH CHARACTERISTICS.—Growth rate very variable, forming a mat 4 to 9 cm., usually 5 to 7 cm., in diameter in 7 days; mat thin, appressed cottony or compacted felty cottony, white becoming "pinkish buff" to "cinnamon-buff" either over entire surface or with color confined to center area and occasionally distributed in concentric rings.

In 14 days mat closely appressed, velvety or fine woolly to downy, forming a thin skin on the agar suface; color very variable, solidly "light buff" or "pinkish buff" with "warm buff" to "cinnamon-buff" patches usually about the inoculum and without agar discolorations; in case a dark-brown discoloration forms in agar, under mat drab gray to smoke gray with crusty "cinnamon" to "cinnamon-drab" irregular areas; no definite odor; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–7μ diameter, thin-walled, clamps numerous, single or multiple; hyphae with multiple clamps readily demonstratable in 7-day-old cultures, becoming obscured in 14 days; nonstaining hyphae 1μ–7μ diameter, hyaline or yellow, smooth- or rough-walled; hyaline or yellowish resinous masses common on both staining and nonstaining hyphae.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 4.8 cm., 20°; 6.8 cm., 25°; 6.1 cm., 30°; 1.3 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant compacted, felty, "pale ochraceous-buff," "warm buff," "cinnamon," "buffy brown," and "saccardo's umber;" on agar cylinder bunchy cottony, "pinkish buff," occasionally "avellaneous."

TYPE OF DECAY.—White sap and heart rot (*12*). Seven hundred and seven isolations.

REMARKS.—Cartwright and Findlay (*10*) described a decay of oaks in England under the name *Stereum spadiceum* Fr. Burt (*4*) considered *S. spadiceum* and *S. gausapatum* as synonymous.

S. gausapatum is sometimes difficult to distinguish from *S. rameale* in culture. However, the former species is usually slower growing, forms a more appressed, thinner mat, without contrasting zones. In test-tube cultures the mat on the slant is typically appressed, felty without loose cottony mycelium.

STEREUM RAMEALE Schw. ex Burt

(Pl. 3, *K;* fig. 6, *G.*)

KEY PATTERN.—B–P–I–1–11–16 and B–P–F–1–11–16.

GROWTH CHARACTERISTICS.—Growth rapid or moderately rapid, forming a mat 8 to 9 cm. or more in diameter in 7 days; mat at first white becoming "vinaceous-buff" to "cream color" or "naples yellow," either solidly colored or with color confined to a central zone, cottony, appressed at center to loose at margins.

In 14 days central zone appressed, fine woolly or felty, tough, "cream-buff," "deep colonial buff," "olive-ocher" or "buckthorn brown;" marginal zone loose, woolly or cottony, often bunchy or floccose, white or "pinkish buff;" no odor; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–8(–10μ)μ diameter, thin-walled, clamps numerous, either simple or multiple; multiple clamps readily seen in 7-day-old cultures, difficult to demonstrate in 14 days; nonstaining hyphae either hyaline 1μ–6μ diameter, smooth; or yellow 2μ–4μ diameter, smooth- or rough-walled; resinous masses common on yellow hyphae.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 5 days in dark at constant temperatures follow: 4.3 cm., 20°; 5.5 cm., 25°; 5.8 cm., 30°; 1.5 c.m, 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on upper part of slant usually white, loose cottony, on lower part compacted, "warm buff," "ochraceous-buff" to "isabella color," and "olive-ochre;" on agar cylinder bunchy cottony, white to "light buff."

TYPE OF DECAY.—White sap rot. Seven isolations.

REMARKS.—*Stereum rameale* resembles *S. gausapatum* somewhat in culture. It may be distinguished by a faster growth rate and a more cottony mat which usually has a definite central zone contrasting markedly in color with rest of mat.

STEREUM SUBPILEATUM Berk. and Curt.

(Pl. 3, *L;* fig. 6, *H.*)

KEY PATTERN.—E–O–M–11–16 and E–P–M–11–16.

GROWTH CHARACTERISTICS.—Growth medium, forming in 14 days a mat 5 to 7 cm. in diameter; central zone extensive, definite, "capucine yellow" and "mikado orange," compacted; appressed, woolly to felty; marginal zone narrow to wide, white, short cottony; margin proper narrow, colorless, appressed, even or slightly fimbriate; odor very pronounced, sweet, musty; oxidase reaction inconsistent, usually positive on gallic acid medium, and negative on tannic acid medium.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–5(–6μ)μ diameter, thin-walled, without clamps, septate; nonstaining hyphae hyaline or

yellow, 1μ–5μ diameter, either with thin walls or thick walls, smooth or rough spiny, intermediate forms common.

TEMPERATURE RELATIONS.—Optimum approximately 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 1.7 cm., 20°; 2.6 cm., 25°; 3.1 cm., 31°; 1.3 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days mat on slant felty to nodulose felty, usually tough, compacted, "ochraceous-orange"; on agar cylinder radiating cottony, "ochraceous-buff" to "capucine yellow."

TYPE OF DECAY.—White pocket rot described by Long (*25*). Three isolations.

REMARKS.—*S. subpileatum* may be readily distinguished from S. *frustulosum* in culture by its appressed, deep-orange mat and by its prominent, sweet, musty odor.

REMARKS.—*Stereum subpileatum* may be readily distinguished from S. *frustulosum* in culture by its appressed, deep-orange mat and by its prominent, sweet, musty odor.

USTULINA VULGARIS Tul.

(Pl. 3, *M;* fig. 6, *I.*)

KEY PATTERN.—F–P–M–8–11–16.

GROWTH CHARACTERISTICS.—Growth medium, forming in 14 days a mat 5 to 7 cm. in diameter, much-compacted, appressed, thin, adherent, forming a thick, wrinkled gelatinous mat on the agar with little or no aerial hyphae, central zone definite or indefinite, usually extensive, "light neutral gray" to "slate-gray;" marginal zone white, appressed, downy; margin proper white, appressed, crenate; odorless; positive oxidase reaction.

HYPHAL CHARACTERISTICS.—Staining hyphae 1μ–4 (–5μ)μ diameter, without clamps, often with prominent hyaline septa; much-coiled hyphae from compacted areas, characteristic, 1μ diameter, nonstaining hyphae usually black, 1μ–2(–4μ)μ diameter, septate, usually broken up into short lengths; hyaline, slightly rough-walled hyphae common in central zone; cuticular cells thin-walled, staining when young, abundant in 7 days, but obscured in older cultures.

TEMPERATURE RELATIONS.—Optimum approximately 25° C. Average mat diameter in 7 days in dark at constant temperatures follow: 3.0 cm., 20°; 4.1 cm., 25°; 2.2 cm., 30°; 0, 35°.

TEST-TUBE CULTURES.—In 28 days mat with a prominent, compacted, much-wrinkled central zone, gray to "dark neutral gray;" and a white, appressed felty or downy marginal zone.

TYPE OF DECAY.—White sap and heart rot, occasionally associated with cankers. Five isolations.

REMARKS.—*Ustulina vulgaris* is characterized in culture by its dark-gray, much-wrinkled, tough mat which lacks aerial hyphae. Microscopically it is distinct, as no other fungus reported here possesses small coiled hyphae or black, nonstaining hyphae.

UNIDENTIFIED AGARIC

(Pl. 3, *N;* fig. 6, *J.*)

KEY PATTERN.—A–O–M–10–16 and A–P–M–10–16.

GROWTH CHARACTERISTICS.—Growth medium, forming in 14 days a mat 8 to 9 cm. in diameter, white, appressed, homogeneous, azonate,

fragile, either without aerial mycelium and water-soaked in appearance or fine woolly to matted cottony; margin appressed, colorless, even; no definite odor; in 17 days negative on gallic acid medium, positive on tannic acid medium.

HYPHAL CHARACTERISTICS.—All hyphae staining, 1μ–7μ diameter, thin-walled, with numerous empty cells, without clamps, septated, with hypha often swollen on one side of septum; hyphae filled with oil droplets common.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 3.6 cm., 20°; 5.5 cm., 25°; 5.2 cm., 30°; 2.6 cm., 35°; 0, 40°.

TEST-TUBE CULTURES.—In 28 days on slant and agar cylinder usually grayish white, matted cottony to cottony, friable, forming a thick submerged mat.

TYPE OF DECAY.—Chiefly associated with a dark discoloration of the wood, usually from the upper trunk, without much evident decay. Six isolations.

REMARKS.—This fungus formed in a 1-year-old flask culture on oak blocks small, normal-appearing white sporophores, which developed very slowly and did not produce basidia or basidiospores.

The hyphal swelling on one side of the septa makes the fungus distinct from all others reported here.

UNIDENTIFIED FUNGUS

(Pl. 3, *O;* fig. 6, *K.*)

KEY PATTERN.—A–P–I–10–16.

GROWTH CHARACTERISTICS.—Growth moderately rapid, forming in 14 days a mat 9 cm. or more in diameter, either colorless, very closely appressed, thin, without aerial mycelium; or with a colorless, appressed central zone and a raised, thin, white radiating-cottony or stranded-cottony marginal zone; odorless; positive oxidase reaction.

In 28 days the surface mycelium becomes denser, white, appressed cottony with scattered crusty, yellowish patches.

HYPHAL CHARACTERISTICS.—Hyphae of one kind, staining, with interspersed empty cells, 2μ–8(–10μ)μ diameter, very thin-walled; clamps few or lacking, in 28 days cuticular cells, thin- or thick-walled, irregular in outline, common in crusty areas; knobbed or much-branched hyphal ends, few or lacking in such areas.

TEMPERATURE RELATIONS.—Optimum between 25° and 30° C. Average mat diameters in 7 days in dark at constant temperatures follow: 4.1 cm., 20°; 6.0 cm., 25°; 6.1 cm., 30°; 2.0 cm., 35°; 0 cm., 41°.

TEST-TUBE CULTURES.—In 28 days mat on slant appressed, colorless, often with crusty yellow areas; on agar cylinder white or yellowish, thin, cottony at times with crusty areas; some isolations form raised mounds of radiating-plumose mycelium on slant and composed of bands of parallel hyphae.

TYPE OF DECAY.—White pocket rot. Seventeen isolations.

REMARKS.—This unidentified fungus has been isolated chiefly from butt specimens, not only from oaks but also from other hardwood species. In culture it bears a close resemblance to *Polyporus zonalis,* forming a similar type of mat. Microscopic structures are also similar. The fungus is, however, quite distinct from *P. zonalis* and to date no transition forms have been encountered. It has never

formed sporophores in culture, therefore its taxonomic position cannot be determined, although it seems highly probable in view of its obvious relationship with *P. zonalis*, that it is a polypore of some kind.

DECAY FUNGI FROM DIFFERENT TYPES OF STANDS

Young Sprout Stands in Eastern States

The relative importance of the fungi from young sprouts and the various factors affecting their prevalence have been fully discussed by Roth and Sleeth (*34*). Table 1 is included, however, so that a comparison can be made with the lists of fungi from other stands. This table also contains some data not included by Roth and Sleeth. *Stereum gausapatum* is the only species of much importance in the younger sprout stands that predominate throughout most of the forest areas of Virginia, Pennsylvania, and New Jersey.

Decay-height figures in combination with number of infections also indicate that from the standpoint of volume of damage *Stereum gausapatum* is by far the most important species. *Armillaria mellea*, the species third in number of infections, causes very little damage, as it does not usually extend above stump height, and it will also be noticed from the last column (table 1) that the mycelium rarely extends much beyond visible decay. *Fistulina hepatica*, which was second in number of infections, was never associated with pronounced decay. Infected wood is darker in color and remains quite hard and firm (*8*, *10*).[13]

The figures on extent of fungus mycelium beyond visible decay give added information as to the importance of the more prevalent species. For most fungi the number of infections was too small for such information to be dependable, but the figures giving average height of visible decay should be significant for most of the species listed.

In these butt rot studies many isolations were also made from heartwood of parent stumps and dead stubs of companion sprouts connected with living trees (table 2). In a great many of these the same fungus was obtained from the parent stump and dead stub as was obtained from the living sprout. The species isolated from stubs and parent stumps connected with sound living sprouts are all species that were also obtained from the living sprouts, and the relative frequency of occurrence is in general similar.

[13] See footnote p. 18.

TABLE 1.—*Statistics on the culturally identified butt rots of young sprout oaks* [1]

Fungi isolated [2]	Host description		Infections in indicated oak species [3]						Infections through indicated avenue of entrance					Average height of visible decay	Height of isolation above visible decay
	Average age	Average diameter at breast height	All	Black	Chestnut	Red	Scarlet	White	Parent stump	Companion sprout	Branch stub	Fire wound	Undetermined		
	Yr.	*In.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*In.*	*In.*
Stereum gausapatum	38	5.8	597	188	36	36	151	186	548	33	6	1	9	57	45
Fistulina hepatica	37	5.2	71	4	2	1	60	4	54	0	0	0	17	12	17
Armillaria mellea	39	6.4	67	10	16	11	9	21	57	2	0	1	7	13	0
Hydnum erinaceus	53	7.9	18	4	3	0	5	6	12	0	2	1	3	64	-----
Stereum frustulosum	55	7.6	18	5	1	1	6	5	8	7	0	0	3	21	23
Poria cocos	39	6.0	17	5	0	1	9	2	14	0	0	0	3	38	-----
Polyporus sulphureus	43	7.2	14	2	1	1	10	0	7	2	1	0	4	23	9
Unidentified fungus	47	6.4	14	3	0	1	4	6	13	0	0	0	1	11	0
Polyporus compactus	33	5.4	11	4	0	1	4	2	9	0	0	1	1	34	-----
Polyporus spraguei	44	8.1	11	0	0	0	11	0	9	0	0	1	1	40	0
Daedalea quiercina	49	9.5	9	0	0	2	4	3	3	4	1	0	1	19	0
Polyporus hispidus	95	11.4	6	1	3	0	0	2	0	0	6	0	0	117	-----
Corticium lividum	59	8.0	4	1	0	0	2	1	2	0	2	0	0	48	-----
Polyporus dryophilus	81	8.6	4	0	3	0	0	1	2	0	1	0	1	248	-----
Polyporus versicolor	48	7.6	4	1	0	0	1	2	0	4	0	0	0	16	-----
Polyporus croceus	51	8.9	3	0	0	1	2	0	2	1	0	0	0	50	-----
Polyporus frondosus	48	6.0	3	0	2	0	0	1	1	0	0	1	1	22	-----
Irpex mollis	81	13.4	2	0	0	0	0	2	0	1	0	0	1	60	-----
Ustulina vulgaris	26	6.4	2	0	0	2	0	0	2	0	0	0	0	27	-----
Fomes everhartii	72	13.0	1	0	0	1	0	0	0	0	0	0	1	156	-----
Pholiota adiposa	40	4.5	1	0	0	0	1	0	0	0	0	0	1	4	-----
Polyporus berkeleyi	30	5.3	1	1	0	0	0	0	1	0	0	0	0	58	-----
Stereum rameale	35	5.1	1	0	0	0	0	1	0	0	1	0	0	0	-----
Total	-----	-----	879	229	67	59	279	245	744	54	20	6	55	-----	-----

[1] Specimens and field data collected by Elmer Roth, Bailey Sleeth, and F. G. Liming.
[2] Arranged in decreasing order of number of infections.
[3] Throughout the bulletin black oak is *Quercus velutina* Lam.; chestnut oak, *Q. montana* Willd.; red oak, *Q. borealis* Mich. f. including *Q. borealis maxima* (Marshall) Ash.; scarlet oak, *Q. coccinea* Münch; white oak, *Q. alba* L.

TABLE 2.—*Fungi isolated from infections in stubs and stumps connected with sound living sprouts*

Fungi isolated	Fungi from indicated areas and substrata					
	Virginia and West Virginia [1]		Pennsylvania, New Jersey, and Connecticut [2]		Total	
	Stump	Stub	Stump	Stub	Stump	Stub
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Stereum gausapatum	46	72	48	11	94	83
Armillaria mellea	19	1	19	4	38	5
Stereum frustulosum	4	6	3	10	7	16
Daedalea quercina	0	1	6	1	6	2
Polyporus versicolor	0	6	1	1	1	7
Unidentified fungus	6	0	0	0	6	0
Fistulina hepatica	1	2	1	0	2	2
Polyporus spraguei	2	2	0	0	2	2
Stereum sp.	0	4	0	0	0	4
Hydnum erinaceus	2	1	0	0	2	1
Hymenochaete rubiginosa	2	1	0	0	2	1
Polyporus sulphureus	2	0	1	0	3	0
Polyporus croceus	0	0	0	2	0	2
Stereum rameale	0	2	0	0	0	2
Pleurotus ostreatus	0	1	0	0	0	1
Poria nigra	0	0	0	1	0	1
Ustulina vulgaris	0	1	0	0	0	1
Total	84	100	79	30	163	130

[1] Samples collected by E. Roth and F. G. Liming. [2] Samples collected by B. Sleeth.

As table 2 includes only cases in which the attached living sprout was sound, the proportion of isolations of such fast-growing species as *Stereum gausapatum* expected from the parent stump connected with such sprouts in relation to those of such slow-growing species as *Armillaria mellea* and the unidentified fungus would be smaller than from decayed sprouts. This actually was the case since *A. mellea* was obtained in about two-fifths as many cases from decayed stumps as was *S. gausapatum* and the unidentified fungus in one-fifteenth as many cases, whereas the relative proportion of these fungi as isolated from living sprouts was about 1 to 9 and 1 to 42, respectively. In older stands where these slower decaying species should have more time in which to advance into the sprout or in younger stands where *S. gausapatum* had not had time to enter the living sprout, this difference might not occur.

Miscellaneous Stands of Eastern and Central States

Many decay samples were received from miscellaneous studies in which the samples were not selected in as uniform manner as were those from the sprout butt rot study. The fungi obtained from such studies are listed in table 3. Information on age of infected trees and on extent of decay as given in this table is not as accurate as that given in table 1. Such information was not recorded for many of the trees sampled but was included when available. In general, the figures on age and diameter breast high can be regarded as fairly reliable as indicated by the fact that *Stereum gausapatum* was obtained from smaller and younger trees than were most of the other fungi.

TABLE 3.—*Statistics on culturally identified rots of oaks from miscellaneous studies*

Fungi isolated [1]	Host description		Infections in indicated oak species								Infections through indicated avenue of entrance					Infections causing indicated type of rot			Average extent of visible decay
	Average age	Average diameter at breast height	All	Black	Chestnut	Post [2]	Red	Scarlet	White	Undetermined oak species	Parent stump	Companion sprout	Branch stub	Fire wound	Undetermined	Top or trunk	Butt rot	Undetermined	
	Yr.	*In.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*In.*
Stereum frustulosum	132	15.6	117	13	0	9	5	10	77	3	0	2	13	42	60	51	52	14	90
Stereum gausapatum	53	8.6	110	10	0	2	36	9	40	13	3	2	7	6	92	20	79	11	35
Hydnum erinaceus	145	14.0	90	8	1	9	3	2	55	12	2	0	11	38	39	17	54	19	79
Poria andersonii	101	11.7	66	22	0	5	2	2	28	7	0	0	37	6	23	48	9	9	96
Polyporus dryophilus	140	14.2	47	5	0	6	2	5	28	1	1	0	11	6	29	32	11	4	136
Polyporus compactus	72	10.3	44	22	0	0	5	5	7	5	0	0	6	14	24	9	16	19	87
Poria cocos	190	20.7	28	3	0	0	6	5	12	2	0	0	0	10	18	1	20	7	70
Polyporus sulphureus	127	16.8	28	3	1	2	10	6	3	3	2	0	1	9	16	1	14	13	132
Armillaria mellea	145	17.2	27	4	2	0	1	1	18	1	2	0	0	9	16	0	27	0	47
Polyporus spraguei	148	18.1	16	2	0	0	8	3	2	1	0	0	0	5	11	0	7	9	77
Poria sp	117	17.1	13	2	3	1	3	0	0	4	0	0	1	2	10	1	2	10	84
Polyporus obtusus	87	9.1	12	3	0	2	0	0	6	1	0	0	4	6	2	3	7	2	61
Poria nigra	116	17.1	12	1	0	0	2	2	6	1	0	0	1	3	8	4	6	2	63
Merulius tremellosus	------	13.7	11	4	0	0	2	3	1	1	2	0	2	5	2	2	7	2	70
Polyporus berkeleyi	256	31.0	10	2	0	0	0	0	8	0	0	0	0	1	9	1	8	1	49
Corticium lividum	120	11.6	8	0	0	1	2	1	1	3	2	0	0	1	5	0	8	0	77
Polyporus frondosus	250	22.5	8	0	0	1	1	1	5	0	0	0	0	1	7	0	3	5	90
Fomes everhartii	------	------	6	3	0	0	2	0	1	0	0	0	0	0	6	5	1	0	------
Unidentified agaric	100	12.5	6	0	0	3	0	0	3	0	0	0	0	0	6	5	1	0	17
Irpex mollis	53	7.5	5	1	0	0	1	0	2	1	0	0	0	0	5	5	0	0	40
Polyporus dryadeus	266	27.5	5	1	0	0	1	0	3	0	0	0	0	1	4	0	4	1	------
Fomes applanatus	------	------	4	1	1	0	0	0	2	0	0	0	0	1	3	1	2	1	------
Fomes robustus	------	------	3	0	0	0	3	0	0	0	0	0	0	0	3	0	0	3	------
Hymenochaete rubiginosa	------	------	3	0	0	3	0	0	0	0	0	0	0	0	3	0	3	0	------
Polyporus graveolens	------	------	3	1	0	0	0	0	0	2	0	0	0	0	3	2	1	0	------
Poria inflata	------	------	3	0	1	0	0	0	2	0	0	0	0	0	3	2	0	1	------
Unidentified fungus	112	22.0	3	0	0	0	1	0	2	0	0	0	0	0	3	0	3	0	56
Stereum subpileatum	------	------	3	1	0	0	1	0	0	1	0	0	1	0	2	2	1	0	------
Ustulina vulgaris	------	------	3	0	0	0	1	0	0	2	0	0	0	0	3	0	3	0	------
Clitocybe illudens [3]	------	------	2	0	0	0	0	0	2	0	0	0	0	0	2	0	2	0	------
Hydnum septentrionale	75	12.0	2	0	0	0	0	0	2	0	0	0	0	0	2	1	1	0	------
Pholiota adiposa	63	7.3	2	0	0	1	0	0	1	0	0	0	0	2	0	0	2	0	------
Polyporus fissilis	108	11.5	2	0	0	0	0	0	1	1	0	0	0	1	1	0	2	0	------

Polyporus gilvus	71	11.4	2	1	0	0	0	0	0	1	0	0	1	0	1	2	0	0	12	
Polyporus versicolor	102	11.3	2	0	1	0	1	0	0	0	0	1	0	1	0	0	2	0		
Stereum rameale	155	14.0	2	0	0	1	0	0	1	0	0	0	0	2	0	0	2	0		
Daedalea quercina	78	17.0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0		
Polyporus croceus	82	30.0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	48	
Total			710	113	10	46	101	57	317	66	14	6	96	172	422	215	362	133		

[1] Arranged in decreasing order of number of infections.
[2] Throughout paper post oak is *Quercus stellata* Wang.
[3] Believed to cause decay in heartwood but not described culturally.

A large proportion of the determinations included in table 3 were from stands located in Missouri and Illinois, part of which were described in detail by Kuenzel and by Limstrom and Kuenzel.[14] Many samples were also obtained from the southern Appalachian region, mostly from old-growth white oaks. Some samples were also obtained from Maryland, Pennsylvania, Ohio, Indiana, and Iowa. Except for a relatively small number from Iowa, the specimens were from trees considerably older than those included in the butt rot study. Usually the stumps were not dissected in an effort to determine the exact source of the butt rot, but in a majority of the studies both top and butt rots were taken into consideration when the trees were felled. Several of the collections were from cut-over areas where stumps only were available for sampling so that the data favor to some extent butt rot fungi over top rot fungi. Many of the trees were not of merchantable size but most of them were old enough to be susceptible to branch infection. It was in these stands and especially those of the Illinois and Missouri areas that *Poria andersonii*, which is primarily a top or trunk-inhabiting species, was frequently obtained. *Stereum frustulosum*, which may enter through either top or butt injuries, was the most prevalent of all fungi. *Hydnum erinaceus* may also be present in the butt or trunk. Poorly stocked stands with larger branches may have been a factor in numerous top infections in these areas. Except in the cases of *Polyporus compactus* and *Poria andersonii*, where a high proportion of the isolations were from black oak, the fungi showed no marked host preferences.

The fairly high incidence of *Stereum gausapatum* was due largely to the Ohio and Iowa areas (table 4). Before the Iowa samples were obtained it was thought that the low incidence of *S. gausapatum* in the Illinois and Missouri areas might be due to unfavorable climatic factors, but the figures from Iowa show that this is not the case. As shown by Roth and Sleeth (*34*), the high incidence of this fungus is undoubtedly due to the presence of parent stumps, which serve as a source of inoculum.

TABLE 4.—*Relative prevalence of Stereum gausapatum among the identifiable infections from several selected areas*

Area	Type of stand	Approximate average age	*Stereum gausapatum* infections	
			Number	Percent of total identifiable infections
		Years		
Iowa [1]	Sprout	34	26	70
Eastern States	do	38	597	68
Ohio	do	[2] 75	35	39
Maryland and Pennsylvania	Mature sprout	[3] 113	8	28
Missouri and Illinois	Sprout [4]	94	27	8
Southern Appalachian	Old-growth white oak	246	12	8

[1] Specimens collected by C. M. Geneaux.
[2] Estimated.
[3] The average age of *Stereum gausapatum* infected trees in this area was 76 years.
[4] Sprouts arising as a result of repeated burning or killing back from other causes.

[14] See footnotes 7 and 8, p. 3.

In order to show more clearly the wide fluctuations in incidence of *Stereum gausapatum*, table 4 has been included. The data are from several isolated stands in the principal areas studied. Accurate tree ages were not given for the Ohio area, but as age is an important factor an approximination of the age is given. It will be seen that the younger stands contained the highest proportion of *S. gausapatum* infections. The difference in proportion of *S. gausapatum* in Ohio, Maryland, and Pennsylvania, on the one hand, and Missouri and Illinois on the other, indicates a difference in origin of stands. As about half of the 27 isolations from Missouri and Illinois were from top rot, the real difference is more striking than shown by the figures. Eleven of the 12 isolations from the southern Appalachian areas were from top rot. This indicates a tendency, in the absence of parent stumps, for *S. gausapatum* to become less important as a butt rot fungus and more important as a top rot fungus as the stands increase in age.

Stands of the Mississippi Delta Region

Much information is lacking on oak decay fungi of the Mississippi Delta region and especially of other areas of the Southern States, as the available data were obtained on relatively few plots in Louisiana and Mississippi. Table 5 gives almost no information regarding trunk- or top-inhabiting species although a number of the species are known, from other studies, to extend throughout much of the lower part of the trunk. Some trunk-inhabiting species such as *Polyporus hispidus* are also known to occur on oak in Louisiana, but were not isolated in these studies.

According to present information, *Fomes geotropus*, *Lentinus tigrinus*, *Polyporus ludovicianus*, and *P. zonalis* are strictly southern species as far as oak decay is concerned.

Table 5.—*Prevalence of different decay fungi isolated from decay in oaks following fires in the Mississippi Delta area*

Fungi isolated [1]	Young trees			Merchantable trees			Total
	Fire-wounded	Undetermined [2]	Total	Fire-wounded	Undetermined [2]	Total	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Fomes geotropus	19	0	19	5	5	10	29
Polyporus lucidus	10	1	11	8	3	11	22
Corticium lividum	9	3	12	2	1	3	15
Lentinus tigrinus	11	1	12	0	0	0	12
Polyporus zonalis	2	0	2	6	2	8	10
Polyporus fissilis	3	0	3	2	4	6	9
Hydnum erinaceus	7	0	7	0	0	0	7
Polyporus ludovicianus	0	0	0	5	1	6	6
Poria inflata	1	0	1	2	3	5	6
Pleurotus ostreatus	[3] 5	0	5	0	0	0	5
Stereum rameale	[4] 4	0	4	0	0	0	4
Armillaria mellea	2	0	2	0	0	0	2
Polyporus pargamenus	[4] 1	0	1	0	0	0	1
Polyporus supinus	[3] 1	0	1	0	0	0	1
Total	75	5	80	30	19	49	129

[1] Listed in decreasing order of number of infections.
[2] Not determined whether wounded.
[3] Sap and heart rot.
[4] Sap rot.

A number of the fungi appear to be of equal importance in young and mature trees, but *Polyporus ludovicianus* and *P. zonalis* were important only in mature trees. It is doubtful whether the figures are representative for all fungi as *Hydnum erinaceus* occurs commonly in older trees of more northerly stands.

Most of these fungi show no marked tendency to a preference for a particular host species except *Corticium lividum*, where 13 of the 15 infections were from overcup oak (*Quercus lyrata* Walter).

Table 5 includes all of the oak fungi listed by Hepting (*18*). *Corticium lividum* is the "yellow hymenomycete" and *Poria inflata* is, in part at least, one of the "white hymenomycetes." The "white hymenomycetes I and II" are believed to have been mostly *Merulius tremellosus*.[15]

Stands Recently Damaged by Fire

Very little information is available regarding the succession of decay fungi in fire wounds. Some indications on this question are given in table 5, where several species are reported as occurring on young fire-wounded trees only, but more pertinent data are given in table 6. Specimens from which these isolations were obtained were collected by R. Kienholz [16] from trees which had been severely wounded 4 years previously. Fungi fruiting on the trees were recorded at the time of cutting and the information was submitted with the specimens.

Table 6.—*Relative prevalence of different fungi isolated from decayed oaks wounded by fire 4 years previously* [1]

Fungi isolated [2]	Trees yielding indicated fungus		Trees with fruiting bodies
	Number	*Percent*	*Number*
Polyporus pargamenus	21	45.7	31
Nummularia spp	6	13.1	4
Stereum rameale	5	10.9	0
Polyporus versicolor	4	8.7	0
Polyporus compactus	2	4.3	0
Stereum gausapatum	2	4.3	0
Stereum spp	2	4.3	8
Unidentified	2	4.3	2
Armillaria mellea	1	2.2	0
Polyporus gilvus	1	2.2	3
Total	46	100.0	48

[1] Specimens and field data collected by R. Kienholz.
[2] Arranged in decreasing order of number of infections.

These isolates were obtained for the most part from typical or incipient decay in the heartwood back of the dead sapwood areas or a short distance above the top of the wound, but in a number of cases the decay ran up just inside the sapwood. Fungi such as *Nummularia* spp. and *Stereum rameale* undoubtedly penetrate only a short distance into heartwood, and their presence is probably due almost entirely to the heavy growth in the dead adjacent sapwood. To a less extent this also is true of such common species as *Polyporus pargamenus* and *P. versicolor*, although for several years after infection these species penetrate the heartwood and cause considerable decay.

[15] Many of these records, especially from merchantable trees, were from unpublished data collected by Frank Kaufert in 1931.
[16] Kienholz, R. Unpublished data.

Two important species of *Nummularia* on oaks are *N. clypeus* (Schw.) Cke. and *N. atropunctata* (Schw.) Hoehn. and the six cases listed may be of these two species. They are among the first fungi to invade sapwood of fire-wounded trees and are constantly associated with a white decay of the sapwood. Twenty-five percent of a number of samples of sapwood sent in by Sleeth from an area burned the same year yielded *Nummularia*. Most of the other 75 percent gave no fungi in culture when isolations were attempted.

The species of *Stereum* fruiting on the wounds were not identified, but probably they were mostly *S. rameale* or *S. fasciatum* Schw. ex Fr. The latter species has not been studied sufficiently for identifications to be made in culture, but it, and probably one or two closely related species, is known to occur commonly in dead sapwood of oaks.

The only typically heartwood-decaying species obtained from these trees were *Armillaria mellea*, *Stereum gausapatum*, and *Polyporus compactus*. These fungi are undoubtedly capable of entering through fire wounds, but probably previous stump or wound infections were involved in some cases.

NON-DECAY-PRODUCING FUNGI IN OAK HEARTWOOD

Many fungi other than wood-decaying species invade heartwood of oaks. Most discolored areas in the heartwood that were connected with a wound or other opening gave in cultures a fairly extensive fungus and bacterial flora. No attempt was made to classify most of these organisms. However, a few were encountered so frequently as to suggest that they might have some effect on entrance and subsequent spread of heartwood-decaying species.

Paecilomyces varioti Bain, or a closely related species, was frequently isolated from brownish streaks at considerable distances from trunk or basal openings, sometimes in association with incipient stages of decay but usually with no active decay present. It was also frequently obtained from brown discolorations around insect tunnels. Its rapid growth over the surface of malt agar makes it difficult to separate or identify any other fungus that might also be present in the wood.

Trichoderma lignorum (Tode) Harz occurs occasionally in decayed heartwood. The present isolations indicate that it enters only after the wood has become thoroughly decayed and possibly only after the activity of the decay fungus has declined. It also grows rapidly and smothers other organisms when planted on agar. *Gliocladium* sp. is similar in general habit of growth and was frequently obtained in culture.

A fungus that is believed by the authors to be the conidial stage of *Coryne sarcoides* Jacq. ex Tul. was frequently isolated from nondecayed discolored heartwood. It forms coremia, which bear conidia in great abundance. The coremia are dark reddish purple in color and sometimes become short-stalked. This fungus usually did not interfere with isolation of decay species.

The most common non-decay-producing fungus isolated from nondecayed heartwood of oaks was a hyphomycete which has never been obtained from any other substratum. It was also obtained from areas of incipient decay and from heartwood that appeared perfectly sound but was slightly discolored. Although it was in

many cases detected growing from wood plantings in agar along with a decay fungus, it was more often the only fungus to appear on agar from apparently sound wood. It grows rather slowly in malt agar with the mycelium and spores almost entirely submerged. In older cultures the surface of the agar becomes covered with slightly raised gelatinous masses of spores, which may become light grayish pink. The spores are produced on numerous, short, much-branched conidiophores. *Torula ligniperda* (Willk.) Sacc. was also occasionally isolated from apparently sound heartwood.

One other non-decay-producing fungus of special interest was consistently isolated from decay caused by *Polyporus hispidus* as reported by Sleeth and Bidwell (*36*) in Connecticut. It has also been consistently associated with *P. hispidus* decay from Pennsylvania, Maryland, Virginia, North Carolina, Louisiana, and Texas. It is apparently present in all parts of the decay but has never been isolated from the margins of sound wood adjacent to the decay except when *P. hispidus* was also present in such areas. Except for one or two isolations from wood decayed by *Poria andersonii*, this fungus has not been obtained from other decay in oak heartwood.

The mycelium of the fungus is sparse, black from the first, with occasional right-angle branches. Later, a raised loose mat of dark mycelium is formed and usually small pycnidial or perithecial primordia having a whorl of long straight mycelial appendages develop. No spores have ever been found either in the pycnidialike structures or on the mycelium. This fungus may grow submerged and almost invisible in the agar under the mat of *Polyporus hispidus* mycelium or it may get a better start and almost smother *P. hispidus*. The fungi have been separated and both grow well in pure culture.

The apparently sound heartwood of most oaks did not contain organisms. A majority of the isolation attempts made from such wood gave no organisms in culture. Most of the samples were obtained from the base of sprout trees so that there was usually some entrance point within a foot or two of where a sample was taken.

DISCUSSION

The main objective in isolation and cultural identification work was to determine which fungi were responsible for decay in oaks. Such information is of value in explaining variations in rate of decay, and it may be useful when correlated with courts of entrance. Table 7, which summarizes data from tables 1, 3, and 5, is intended to give a more accurate picture of the relative prevalence of the oak heart-rotting fungi in the regions studied. In only a few minor instances do the fungi show any marked host species preference. For this reason the geographic distribution (table 7) has been substituted for host distribution.

A total of 48 fungi are listed as having been isolated from heartwood. Six of these, including *Stereum rameale*, *Polyporus pargamenus*, and *P. supinus* Sw. ex Fr., are principally saprophytic species of very little importance in heartwood but at least 42 commonly infect heartwood.

Long (*23*), who studied decay in mature white oak principally, mentioned finding 20 different kinds of rot, and of the 8 he lists as being of considerable importance only 2 are represented in the first

8 of the list presented here. If *Stereum frustulosum* were substituted for *Polyporus pilotae* in Long's list, his 5 principal butt rot species would correspond fairly well with the more prevalent species in table 7.

TABLE 7.—*Distribution of infections from decayed heartwood of oaks in different areas* [1]

Fungi isolated [2]	Total infections	Infections in indicated areas						
		All	Northeast [3]	Alleghenny [4]	Appalachian [5]	Mississippi Delta [6]	Middle West [7]	Lake States [8]
	Percent	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Stereum gausapatum	41.2	707	22	238	357	0	88	2
Stereum frustulosum	7.9	135	3	10	56	0	66	0
Hydnum erinaceus	6.7	115	0	8	32	7	66	2
Armillaria mellea	5.6	96	10	20	52	2	8	4
Fistulina hepatica	4.1	71	21	16	34	0	0	0
Poria andersonii	3.8	66	0	0	12	0	53	1
Polyporus compactus	3.2	55	1	0	11	0	32	11
Polyporus dryophilus	3.0	51	0	1	23	0	27	0
Poria cocos	2.6	45	0	5	25	0	15	0
Polyporus sulphureus	2.4	42	2	8	8	0	22	2
Fomes geotropus	1.7	29	0	0	0	29	0	0
Corticium lividum	1.6	27	0	1	4	15	7	0
Polyporus spraguei	1.6	27	4	5	5	0	13	0
Polyporus lucidus	1.3	22	0	0	0	22	0	0
Unidentified fungus	1.0	17	0	6	11	0	0	0
Poria sp.	.76	13	0	0	0	0	12	1
Lentinus tigrinus	.70	12	0	0	0	12	0	0
Poria nigra	.70	12	0	0	6	0	6	0
Polyporus obtusus	.70	12	0	0	1	0	10	1
Polyporus berkeleyi	.64	11	1	1	8	0	1	0
Polyporus fissilis	.64	11	0	0	0	9	2	0
Polyporus frondosus	.64	11	0	2	5	0	4	0
Merulius tremellosus	.64	11	0	0	1	0	8	2
Daedalea quercina	.58	10	4	5	1	0	0	0
Polyporus zonalis	.58	10	0	0	0	10	0	0
Poria inflata	.52	9	0	0	3	6	0	0
Fomes everhartii	.40	7	1	0	1	0	3	2
Irpex mollis	.40	7	0	2	2	0	2	1
Stereum rameale	.40	7	0	1	1	4	1	0
Unidentified agaric	.35	6	0	0	0	0	6	0
Polyporus ludovicianus	.35	6	0	0	0	6	0	0
Polyporus versicolor	.35	6	1	3	1	0	1	0
Polyporus hispidus	.35	6	0	5	1	0	0	0
Polyporus dryadeus	.29	5	0	1	3	0	1	0
Ustulina vulgaris	.29	5	0	1	1	0	3	0
Pleurotus ostreatus	.29	5	0	0	0	5	0	0
Fomes applanatus	.23	4	0	0	3	0	1	0
Polyporus croceus	.23	4	0	3	1	0	0	0
Fomes robustus	.17	3	0	0	2	0	0	1
Hymenochaete rubiginosa	.17	3	0	0	0	0	3	0
Polyporus graveolens	.17	3	0	1	1	0	1	0
Stereum subpileatum	.17	3	0	0	1	0	2	0
Pholiota adiposa	.17	3	1	0	0	0	2	0
Clitocybe illudens	.10	2	0	0	2	0	0	0
Hydnum septentrionale	.10	2	0	0	1	0	0	1
Polyporus gilvus	.10	2	0	0	0	0	2	0
Polyporus pargamenus	.06	1	0	0	0	1	0	0
Polyporus supinus	.06	1	0	0	0	1	0	0
Total	100.00	1,718	71	343	676	129	468	31

[1] Summary of infections included in tables 1, 3, and 5.
[2] Arranged in decreasing order of number of infections.
[3] Includes Connecticut and New York.
[4] Includes Maryland, New Jersey, and Pennsylvania.
[5] Includes Kentucky, North Carolina, South Carolina, Virginia, and West Virginia.
[6] Includes Louisiana and Mississippi.
[7] Includes Illinois, Indiana, Iowa, Missouri, and Ohio.
[8] Includes Michigan, Minnesota, and Wisconsin.

Polyporus pilotae is included here as *P. croceus* and was seldom obtained in culture. Because Long did not include *Stereum frustulosum* in his lists it seems probable that some of the decay he listed as *P. pilotae* was *S. frustulosum* and it is also likely that some of that

listed as *Hydnumerinaceus* was caused by *S. frustulosum*. Incipient stages of decay caused by the last two fungi are somewhat similar and in some samples it was thought that both fungi may have been present. Hedgcock (*16*) gave *Polyporus dryophilus* as the most important species and *Fomes everhartii* as second in importance.

Hepting (*18*) listed 9 fungi isolated from southern oaks and this same information, with additions from Kaufert's isolations, is here included in table 7. Hepting and Hedgcock (*19*) listed 23 fungi as occurring in oaks in the Appalachian region but made no attempt to determine their relative prevalence. The information given by Boyce (*3, p. 401*) is taken almost entirely from the above-mentioned studies.

The list given in table 7 is not representative for any single area or any one type of stand. For young sprout stands in Eastern and Central States, which have parent stumps as a possible entrance point, the figures given for the Allegheny area should be fairly representative. For similar seedling stands free from infection through the parent stump the figures given for the Middle West should be nearly representative. For older stands of sprout oaks the Appalachian records should be more representative. For older stands having many fire wounds or large branch stubs as entrance points the data from the Middle West should more nearly fit except that the number of *Stereum gausapatum* infections is greater than would be expected.

The figures given for *Polyporus hispidus, P. dryadeus, P. graveolens, Fomes applanatus, F. everhartii, F. robustus,* and *Hydnum septentrionale* do not necessarily represent their relative prevalence, as some of the trees were selected because of the presence of sporophores.

Fomes everhartii and *Polyporus hispidus,* which are usually thought of as common oak decay fungi, were seldom isolated from trees during these studies. Neither sporophores nor cultures of *F. igniarius,* reported by some on oaks, were obtained in these studies.

SUMMARY

Many isolates of oak heart-rotting fungi were obtained from trees in various localities of the Central, Eastern, and Southern States. It was possible to identify all of the more important species from their characteristics in pure culture, and from this information the relative prevalence of the various species was more accurately determined.

Stereum gausapatum was the most important species causing butt rot in young sprout oak stands in the Eastern States where parent stumps were the main source of infection. *Armillaria mellea, Fistulina hepatica,* and *Stereum frustulosum* were other species frequently encountered.

From somewhat older stands in the Central and Eastern States and where parent stumps were usually not a factor but where fire wounds were common, *Stereum frustulosum, Hydnum erinaceus, Poria andersonii, P. cocos, Polyporus dryophilus, P. compactus,* and *P. sulphureus* were the species most commonly isolated. Trunk- or top-inhabiting species such as *Poria andersonii* and *Polyporus dryophilus* were important on the areas sampled in the Central States. *Stereum frustulosum* and *Hydnum erinaceus* apparently enter at the base of the trees, higher up in the trunk, or through large branches in the top. *Stereum gausapatum* was of little importance as a butt-inhabiting species in stands lacking large persistent parent stumps. It was of

some importance as a top-inhabiting species in mature- or old-growth stands.

The heart rots of oaks in the southern delta region were mostly caused by species not commonly present in the other areas sampled. In young fire-wounded stands *Fomes geotropus*, *Lentinus tigrinus*, *Corticium lividum*, and *Polyporus lucidus* were the species frequently present. In similar older stands *Fomes geotropus* and *Polyporus lucidus* were the more prevalent, but *P. zonalis*, *P. fissilis*, *P. ludovicianus*, and *Poria inflata* were also of considerable importance. Most of these infections occurred through fire wounds.

Seventeen hundred and eighteen classified oak decay infections were obtained from all areas sampled: 707 were caused by *Stereum gausapatum*, 135 by *S. frustulosum*, 115 by *Hydnum erinaceus*, 96 by *Armillaria mellea*, 71 by *Fistulina hepatica*, 66 by *Poria andersonii*, 55 by *Polyporus compactus*, 51 by *P. dryophilus*, 45 by *Poria cocos*, 42 by *Polyporus sulphureus*, 29 by *Fomes geotropus*, 27 by *Corticium lividum*, 27 by *Polyporus spraguei*, and 22 by *P. lucidus*. Thirty-four less prevalent species accounted for from 17 to 1 infection each. *Fomes everhartii*, *F. applanatus*, *F. robustus*, and *Polyporus hispidus*, which are commonly found fruiting on living trees, were seldom obtained from decay samples from the various areas.

Many of the samples of decay yielded only molds or other non-decay-producing fungi and bacteria in culture. No organisms were obtained from some decay samples and occasionally several decay fungi were present in the same sample.

Some information on extent of damage caused by the different fungi was obtained, but in many cases this information is not believed to be sufficiently accurate or represents too few samples to be reliable. Such species as *Armillaria mellea* and the unidentified fungus cause very little damage as they are usually confined to small areas in the base of the tree. *Fistulina hepatica* does not cause a pronounced decay. Most of the other more prevalent species are known to cause considerable damage.

The fungi isolated exhibited very little tendency to host species preference. *Fistulina hepatica* was usually obtained from scarlet oak, and *Corticium lividum* was confined in the South almost entirely to overcup oak.

The various fungi were identified rather readily after their cultural characteristics were definitely established. A key based on both macroscopic and microscopic characters in pure culture was arranged as an aid to identification, and detailed descriptions of the cultural characteristics of each species were made to serve as a basis for the isolation method of decay diagnosis.

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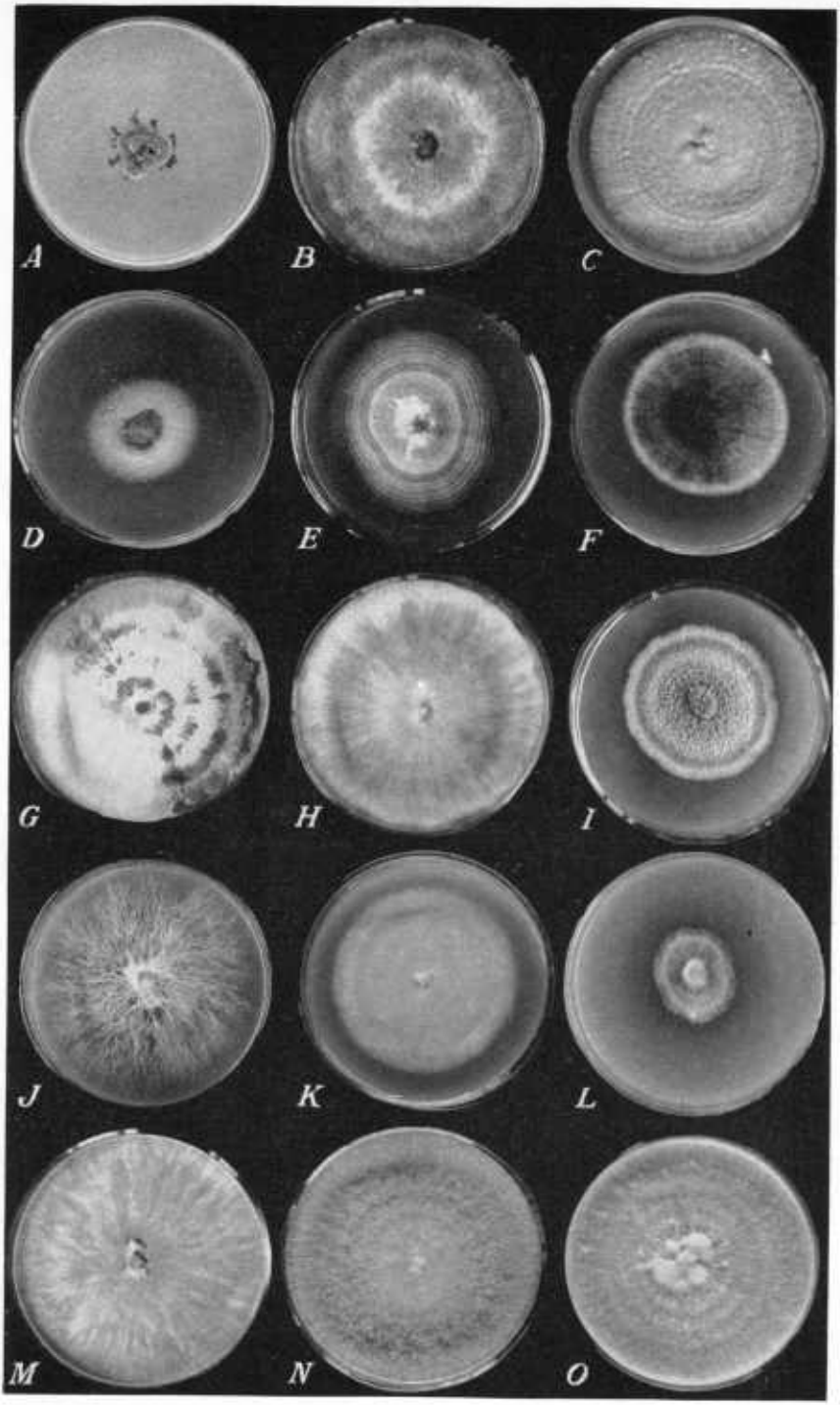
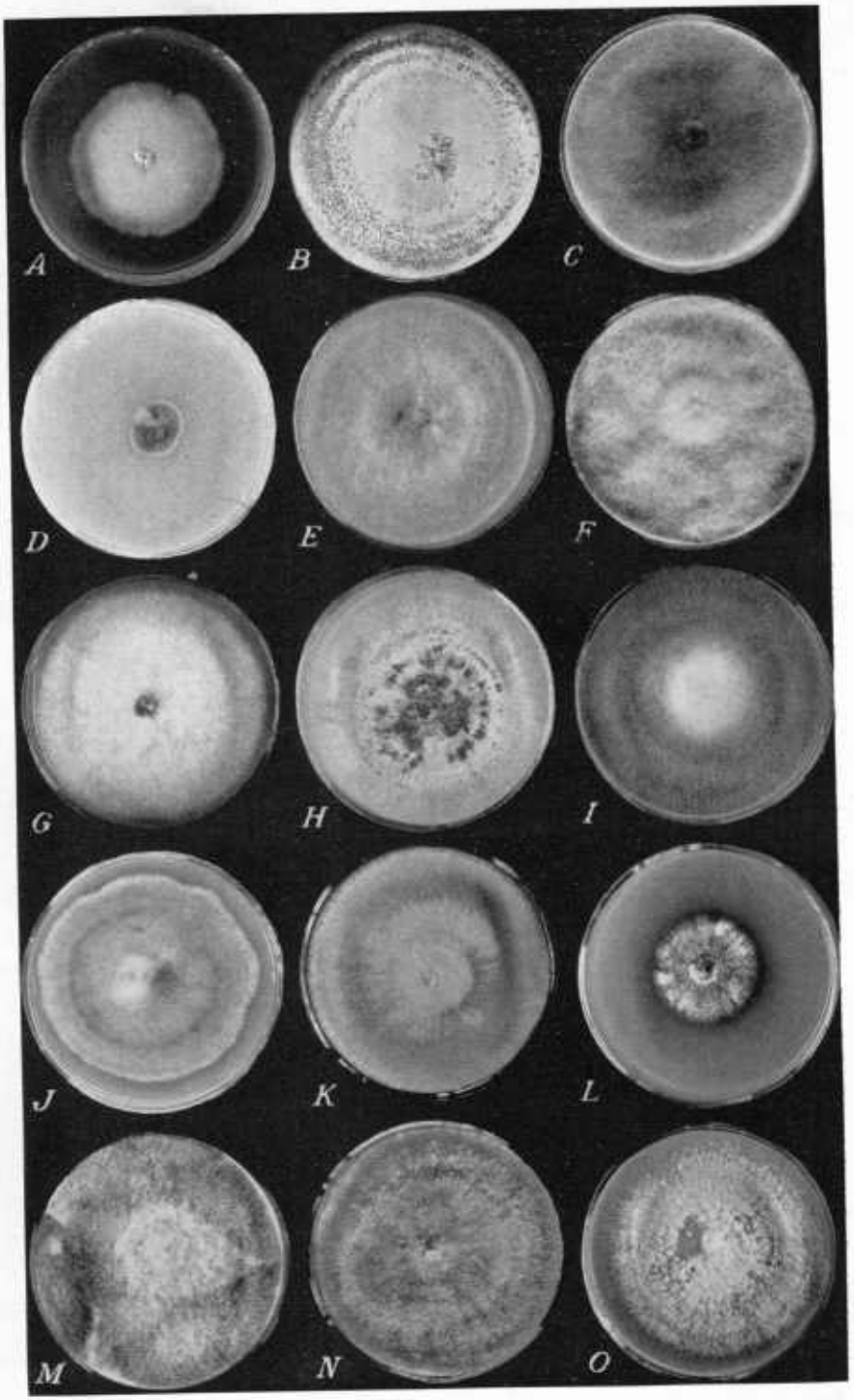
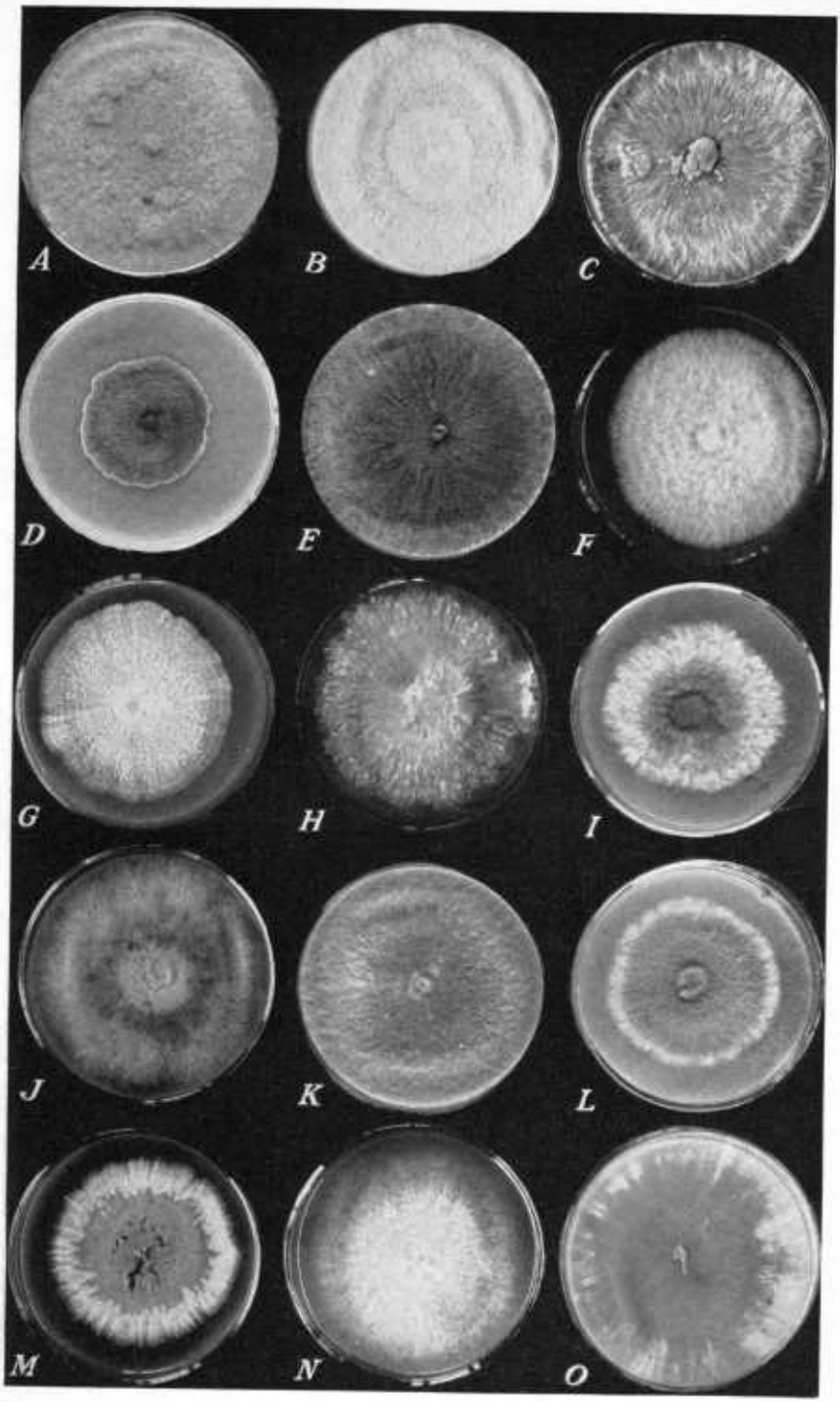


Mats on malt agar, in diffused light, at room temperature; age 14 days: *A, Armillaria mellea; B, Corticium lividum; C, Daedalea quercina; D, Fistulina hepatica; E, Fomes applanatus; F, F. everhartii; G, F. geotropus; H, F. lobatus; I, F. robustus; J, Hydnum erinaceus; K, H. septentrionale; L, Hymenochaete rubiginosa; M, Merulius tremellosus; N, Pholiota adiposa; O, Pleurotus ostreatus.* Photographs by M. L. F. Foubert.



Mats on malt agar, in diffused light, at room temperature; age 14 days: *A*, *Polyporus berkeleyi*; *B*, *P. compactus*; *C*, *P. croceus*; *D*, *P. dryadeus*; *E*, *P. dryophilus*; *F*, *P. fissilis*; *G*, *P. frondosus*; *H*, *P. gilvus*; *I*, *P. graveolens*; *J*, *P. hispidus*; *K*, *P. lucidus*; *L*, *P. ludovicianus*; *M*, *P. obtusus*; *N*, *Poria inflata*; *O*, *Polyporus spraguei*.



Mats on malt agar, in diffused light, at room temperature; age 14 days unless otherwise stated: *A*, *Polyporus sulphureus*; *B*, *P. versicolor*; *C*, *P. zonalis*; *D*, *Poria andersonii*; *E*, *P. cocos*; *F*, *P. nigra*, age 10 days; *G*, *Poria* sp.; *H*, *Schizophyllum commune*; *I*, *Stereum frustulosum*; *J*, *S. gausapatum*; *K*, *S. rameale*; *L*, *S. subpileatum*; *M*, *Ustulina vulgaris*; *N*, Unidentified agaric; *O*, Unidentified fungus.